SECTION 6

MANAGEMENT RECOMMENDATIONS

6.1 Issues and Concerns

As discussed in the previous sections, a variety of problems and issues currently exist for Lake Lafayette. However, for discussion purposes, the observed problems and issues are divided into five categories, including: (1) protection of water quality characteristics within the sink areas; (2) water quality violations; (3) excessive nutrient loadings; (4) artificial compartmentalization of Lake Lafayette; and (5) public access. A brief discussion of these issues is given in the following sections.

6.1.1 Water Quality Protection for Sinks

Virtually all interested parties and stakeholders agree that the foremost concern affecting Lake Lafayette at this time is protection of water quality characteristics in the sink areas within Upper Lake Lafayette. It is believed that the sink areas beneath Upper Lake Lafayette have a direct hydraulic connection with deeper underground aquifers. Upper layers of these aquifers are utilized as potable water sources by individual homeowners, while deeper aquifer areas are utilized by municipalities downgradient of the sinks for public water supply. Although no current studies have indicated that degradation of these aquifers have occurred as a result of inputs into the sinks, concern has been raised over future impacts to aquifer water quality if the current practice of discharging untreated stormwater runoff into the sinks continues.

Tributary inflows and direct runoff inputs into Upper Lake Lafayette contribute a multitude of both inorganic and organic constituents into Upper Lake Lafayette. Based upon the hydrologic budget for Upper Lake Lafayette, presented in Section 3, the vast majority of these inputs infiltrate directly into groundwater through the main sink, smaller sinks, and the porous lake bottom. As discussed in Section 4, both baseflow and stormwater inputs into Upper Lake Lafayette have exhibited periodic to frequent violations of Class III surface water criteria for turbidity, fecal coliform bacteria, cadmium, and copper. It is likely that measurable quantities of pesticides, herbicides, and other synthetic organic compounds are also present. Therefore, work efforts need to be performed in and around Upper lake Lafayette to minimize impacts of stormwater runoff on the sinks and the underlying aquifer.

6.1.2 Water Quality Violations

A summary of significant water quality concerns and violations of Class III surface water criteria observed in the four compartments of Lake Lafayette is given in Table 6-1. In Upper Lake Lafayette, water quality violations have been observed in baseflow inputs originating from Weems Pond for fecal coliform, *E. Coli*, cadmium, copper, and turbidity. Although a water quality criterion does not currently exist for *E. Coli* in the Class III surface water standards, the U.S. EPA has established a recommended criterion of 116 cfu/100 ml for recreational waterbodies. Using this criterion, water quality concerns with *E. Coli* were present during 21% of the measured baseflow samples. Baseflow inputs from Lafayette Creek exhibited water quality violations for fecal coliform, copper, cadmium, and *E. Coli*. Stormwater inputs from Weems Pond have exhibited water quality violations for fecal coliform, copper, zinc, and *E. coli*, while runoff inputs from Lafayette Creek have exhibited water quality violations for turbidity, fecal coliform, *E. Coli*, copper, and zinc.

No significant tributary inflows discharge into Lake Piney Z, so water quality concerns are based upon the monthly surface water monitoring performed in this compartment. During the monthly monitoring program, Lake Piney Z exhibited chronic conditions of low dissolved oxygen, with periodic water quality violations for *E. Coli* and elevated levels of BOD. The current Class III standard for BOD does not contain a specific numerical criterion, but states that BOD shall not be increased to levels which would cause dissolved oxygen to be depressed below the limit established (5 mg/l). It is generally recognized that BOD levels in excess of 5 mg/l are capable of causing oxygen depletion to the point where the dissolved oxygen criterion is likely to be violated. Therefore, for purposes of this analysis, BOD concentrations in excess of 5 mg/l are assumed to be a water quality concern.

TABLE 6-1

WATER QUALITY CONCERNS AND VIOLATIONS IN THE FOUR COMPARTMENTS OF LAKE LAFAYETTE

COMPARTMENT	WATER QUALITY CONCERNS / VIOLATIONS			EXCEEDANCES OF STANDARD[1] (%)
	SAMPLE	LOCATION	PARAMETER	
Upper Lake Lafayette	Baseflow	Weems Pond	Fecal Coliform *E. Coli* Cadmium Copper Turbidity	26 21 8 41 3
		Lafayette Creek	Fecal Coliform *E. Coli* Copper Cadmium	15 58 54 8
	Stormwater	Weems Pond	Fecal Coliform *E. Coli* Copper Zinc	22 19 78 16
		Lafayette Creek	Turbidity Fecal Coliform *E. Coli* Copper Zinc	50 30 60 55 15
Lake Piney Z	Surface Water	*E. Coli* Low Dissolved Oxygen (< 5 mg/l) Elevated BOD (> 5 mg/l)		14 71 7
Alford Arm	Baseflow	*E. Coli* Cadmium Copper Elevated BOD (> 5 mg/l)		16 8 60 8
	Stormwater	Fecal Coliform *E. Coli* Copper		29 7 43
	Surface Water	Fecal Coliform Low Dissolved Oxygen (< 5 mg/l) Elevated BOD (> 5 mg/l)		20 92 8
Lower Lake Lafayette	Outfall Canal	Fecal Coliform Copper Cadmium Elevated BOD (> 5 mg/l)		7 63 7 4

1. Percentage of collected samples

Baseflow inputs through Alford Arm tributary exhibited water quality violations for *E. Coli*, cadmium, copper, and elevated BOD, while stormwater inputs exhibited violations for fecal coliform, *E. Coli*, and copper. Based upon the monthly surface water monitoring program, surface water within Alford Arm exhibited water quality violations for fecal coliform, with chronic observed conditions for low dissolved oxygen and period conditions of elevated BOD.

Water quality monitoring in Lower Lake Lafayette was performed at the Outfall Canal as part of the baseflow monitoring at this location. Based upon the results of this monitoring program, chronic exceedances of the Class III criterion were observed for copper, with infrequent exceedances observed for fecal coliform, cadmium, and conditions of elevated BOD.

In summary, each of the four compartments of Lake Lafayette has exhibited at least periodic violations for microbiological parameters, cadmium, and copper. In addition to these parameters, chronic conditions of low dissolved oxygen and elevated BOD concentrations are present in Lake Piney Z, Alford Arm, and Lower Lake Lafayette.

6.1.3 Excessive Nutrient Loadings

Estimates of annual nutrient loadings to each of the four compartments of Lake Lafayette from July 2003-June 2004 were previously summarized in Section 4. A comparison of estimated total and areal loadings of nitrogen and phosphorus to the four compartments of Lake Lafayette is given in Table 6-2. Loadings are provided for both nitrogen and phosphorus in terms of kg/yr and also expressed as an areal loading rate in terms of g/m^2-yr. Estimates of permissible loading levels (Vollenweider, 1968) for both phosphorus and nitrogen are summarized at the bottom of Table 6-2.

As seen in Table 6-2, phosphorus loadings to each of the four compartments of Lake Lafayette exceed the permissible areal loading rate, recommended by Vollenweider, of 0.1 g/m^2-yr. In fact, phosphorus loadings in three of the four compartments exceed the dangerous level of 0.2 g/m^2-yr where eutrophic water quality characteristics would be expected. The dangerous loading level is exceeded by approximately 700% in Upper Lake Lafayette, 160% in Alford Arm, and 40% in Lower Lake Lafayette. This excessive phosphorus loading is capable of stimulating the growth of aquatic vegetation in Alford Arm and Lower Lake Lafayette and both aquatic vegetation and pelagic algae in Lake Piney Z.

TABLE 6-2

COMPARISON OF ESTIMATED TOTAL AND AREAL LOADINGS OF NITROGEN AND PHOSPHORUS TO LAKE LAFAYETTE FROM JULY 2003-JUNE 2004

COMPARTMENT	LAKE AREA (acres)	PHOSPHORUS LOADING		NITROGEN LOADING	
		kg/yr	g/m^2-yr	kg/yr	g/m^2-yr
Upper Lake Lafayette	373	2,409	1.60	12,114	8.02
Lake Piney Z	231	112	0.12	1,568	1.68
Alford Arm	367	773	0.52	5,723	3.85
Lower Lake Lafayette	1,027	1,181	0.28	11,519	2.77

Permissible Loading Levels (Vollenweider, 1968) for Lakes up to 15 m Deep:

1. Phosphorus: a. Permissible: < 0.1 g/m^2-yr
   b. Dangerous: > 0.2 g/m^2-yr

2. Nitrogen: a. Permissible: < 1.5 g/m^2-yr
   b. Dangerous: > 3.0 g/m^2-yr

Based upon the surface water quality monitoring performed in Lake Piney Z, Alford Arm, and Lower Lake Lafayette from July 2003-July 2004, Lake Lafayette appears to exhibit primarily nutrient-balanced conditions which means that inputs of both phosphorus and nitrogen and capable of stimulating primary productivity within the lake. A comparison of nitrogen loadings is also provided in Table 6-2. Calculated areal nitrogen loadings in each of the four compartments exceeds the permissible level of nitrogen loadings recommended by Vollenweider, with nitrogen loadings in Upper Lake Lafayette and Alford Arm exceeding the dangerous loading level of 3.0 g/m^2-yr. The compartment with the lowest existing loadings of nitrogen and phosphorus appear to be Lake Piney Z which exhibits areal loadings for both nitrogen and phosphorus just slightly above the permissible threshold recommended by Vollenweider. The most elevated phosphorus loadings occur in Upper Lake Lafayette which exceeds the permissible phosphorus loading by a factor of 16 and the dangerous phosphorus loading by a factor of 8. Similarly, areal nitrogen loading in Upper Lake Lafayette exceeds the permissible level established by Vollenweider by a factor of 5 and exceeds the dangerous loading level by a factor of 2.7.

Areal loadings of nitrogen and phosphorus appear to be excessive in each of the four compartments of the lake, particularly in Upper Lake Lafayette and Alford Arm. Nutrient inputs and loadings into Lake Lafayette need to be reduced to control the excess plant productivity which currently is a problem in Lake Piney Z, Alford Arm, and Lower Lake Lafayette.

6.1.4 Artificial Compartmentalization of Lake Lafayette

As discussed in Section 2, Lake Lafayette was historically part of a 2600-acre wetland system. Over time, the bottom of the lake has been compartmentalized, using a series of earthen berms along with construction of the CSX railroad, into four separate compartments, each of which has distinct and unique characteristics.

In the various meetings held during the course of this project, the Lake Lafayette Stakeholders have been vocal in suggesting that elimination of the compartmentalization of Lake Lafayette would be beneficial for both water quality and for the lake ecosystem in general. However, elimination of the compartmentalization would require coordination from a variety of public and private entities and would likely face a multitude of permitting hurdles.

6.1.5 Public Access

One of the biggest concerns on the part of many of the Lake Lafayette Stakeholders is the lack of significant public access into the lake. Lands in public ownership currently exist around each of the four lake compartments. However, access through these public lands is either limited or difficult due to lack of adequate roads and facilities.

6.2 "Do Nothing" Alternative

Estimates of nutrient and pollutant loadings to the four compartments of Lake Lafayette were generated for assumed future conditions to evaluate changes in anticipated mass loadings and water quality characteristics if no significant management alternatives are implemented within Lake Lafayette or the Lake Lafayette watershed. The methodology outlined in the previous sections, along with the LLNSLMMM model, was used to evaluate future conditions.

Changes in mass loadings generated within the Lake Lafayette watershed under future conditions are based upon anticipated changes in land use characteristics provided to ERD by the Tallahassee-Leon County GIS Department. A listing of assumed future land use in the Lake Lafayette drainage basin is given in Table 6-3, and a summary of anticipated changes in land use characteristics within the Lake Lafayette watershed is given in Table 6-4. The largest increases in land use under future conditions will occur in the low-density, medium-density, and high-density residential categories. Under future conditions, these three categories will comprise approximately 64% of the land use within the Lake Lafayette watershed. Additional smaller increases in land use are proposed for industrial, low-intensity commercial, high-intensity commercial, and multi-family residential. The proposed future development will occur at the expense of existing open space which will decrease by approximately 13,481 acres, representing 21% of the Lake Lafayette basin under future conditions compared with 47.3% under existing conditions.

In addition to the previously described changes in land use characteristics, changes are also anticipated in the amount of impervious area and directly connected impervious areas (DCIA) associated with future development compared with existing conditions. A comparison of percent impervious and DCIA assumptions for existing and future conditions is given in Table 6-5. Existing assumptions for impervious areas and DCIA are provided for each of the land use categories included in the LLNSLMM model. This information is based upon evaluation of existing aerial photography, combined with field inspections, for typical development within the City of Tallahassee and Leon County. Much of this information was generated by the City of Tallahassee during development of the CoTNSLM model.

TABLE 6-3

ASSUMED FUTURE LAND USE IN THE LAKE LAFAYETTE DRAINAGE BASIN

SUB-BASIN	LAND USE AREA (acres)												
	Low-Density Residential	Medium-Density Residential	High-Density Residential	Multi-Family Residential	High-Intensity Commercial	Low-Intensity Commercial	Industrial	Highway / Federal	Highway / Interstate	Highway / Major	Rec/ Open Space	Open Water/ Lake	Total
Alford Arm	677.6	253.8	0.8	0.0	0.0	29.3	68.1	0.0	0.0	16.3	1120.2	57.9	2224.0
Betton Woods	209.6	313.1	273.6	126.8	63.0	155.9	20.1	21.8	0.0	23.4	275.3	5.9	1488.5
Buck Lake CB	210.0	99.3	38.1	6.1	0.0	1.1	0.0	28.6	0.0	15.1	115.9	38.3	552.5
Capital Medical Center PCB	8.9	2.9	5.3	82.6	0.1	56.6	0.0	4.2	0.0	7.4	75.5	9.6	253.1
Celebration Baptist Church CB	0.0	2.9	0.0	0.0	0.0	14.2	0.0	0.0	0.0	0.6	0.0	0.0	17.6
Desoto Lakes	570.9	264.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.9	170.7	28.6	1047.1
East 27 CB	50.3	1.8	0.0	0.0	24.3	0.0	0.0	0.0	0.0	3.3	190.1	0.0	269.8
East Park Avenue	123.6	433.9	167.5	311.9	211.6	318.6	95.3	79.9	0.0	21.8	872.1	7.4	2643.7
East Spring Church	540.5	15.6	0.2	0.0	0.0	0.6	534.0	0.0	0.0	8.7	-74.3	12.9	1038.1
Federal Correctional Institution CB	0.0	0.0	0.0	0.0	0.0	84.6	3.9	13.0	0.0	0.0	5.1	0.0	106.7
Foley Drive CB	0.0	25.9	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.9	0.0	29.5
Gilbert Pond	415.1	219.7	4.3	4.8	15.0	12.1	1.0	1.3	0.0	9.7	109.2	99.9	892.1
Goose Pond	543.6	636.6	506.4	115.3	105.3	226.7	58.1	48.4	77.5	12.4	175.6	39.0	2545.0
Harriman Circle PCB	37.6	88.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	19.0	0.9	145.8
I-10/90	1835.2	351.3	1646.7	14.6	16.9	57.1	333.2	83.3	211.7	27.6	576.3	105.3	5259.1
Killarney Plaza PCB	0.0	10.0	0.8	3.7	0.0	15.5	0.0	0.0	0.0	0.0	0.3	0.0	30.2
Lafayette Oaks CB	346.6	206.7	0.0	0.0	0.0	13.6	0.0	9.7	0.0	17.4	142.5	9.9	746.5
Lake Ella PCB	8.2	30.7	16.3	10.6	30.8	52.7	3.7	7.4	0.0	3.4	30.8	11.7	206.3
Lake Heritage	67.9	216.4	10.1	10.2	0.0	15.2	2.7	5.9	0.0	10.0	194.4	40.5	573.3
Lake Kanturk	75.0	329.1	0.9	0.0	0.0	0.8	0.0	0.0	0.0	3.8	10.7	80.9	501.2
Lake Killarney	46.9	561.6	47.4	40.9	0.0	0.6	0.0	0.0	0.0	0.3	283.1	86.8	1067.6
Lake Kinsale	2.7	65.7	21.6	1.0	8.9	13.4	0.4	0.0	0.0	0.0	23.1	11.1	147.9
Lake McBride	549.9	247.4	11.0	11.1	16.4	30.3	2.4	12.0	0.0	4.1	170.2	201.1	1256.0
Lake Saratoga	407.4	335.9	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.9	212.6	14.7	974.5
Lake Sheelin PCB	0.0	185.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.6	6.6	214.1
Lake Tom John	248.9	267.2	3.2	1.4	0.9	2.8	0.3	0.0	0.0	0.0	-15.3	63.9	573.2
Lincoln High	232.7	69.5	84.1	80.7	30.2	185.4	11.3	32.7	0.0	4.7	1051.0	16.8	1799.1
Lower Kanturk	9.7	2.7	456.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	231.2	6.6	715.2
Lower Lafayette	435.8	71.3	2.1	0.0	0.0	25.2	71.0	44.2	0.0	16.2	1584.8	49.3	2300.0
Martinez	2683.9	28.9	94.2	1.0	0.6	9.7	1.4	0.0	0.0	32.8	0.0	43.6	2896.2

Attachment # 1
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TABLE 6-3 -- CONTINUED

ASSUMED FUTURE LAND USE IN THE LAKE LAFAYETTE DRAINAGE BASIN

SUB-BASIN	LAND USE AREA (acres)												
	Low-Density Residential	Medium-Density Residential	High-Density Residential	Multi-Family Residential	High-Intensity Commercial	Low-Intensity Commercial	Industrial	Highway / Federal	Highway / Interstate	Highway / Major	Rec/ Open Space	Open Water/ Lake	Total
Maylor CB	155.4	77.8	8.8	9.8	0.7	22.0	0.0	0.0	0.0	10.7	95.0	1.6	381.7
McCord Park	180.8	525.3	91.0	97.2	20.7	83.2	14.4	0.0	0.0	17.0	108.8	2.8	1141.1
Melody Hills PCB	0.7	10.0	46.1	5.4	1.1	50.7	0.0	6.8	0.0	0.4	55.6	0.0	177.0
Miles	1161.5	0.5	279.3	0.0	0.0	0.0	2.4	0.0	0.0	14.7	0.0	33.6	1492.0
Millstone Creek	850.3	454.2	52.7	29.7	26.9	104.2	6.1	29.8	0.0	10.1	111.5	17.6	1693.1
Mom and Dads CB	627.2	24.9	32.2	1.3	0.0	24.4	4.7	16.8	0.0	5.7	1.1	33.4	771.6
Moore Pond CB	149.4	236.8	14.0	0.1	0.0	12.9	0.0	0.0	0.0	8.8	64.2	37.1	523.3
Mt. Hornbem	61.5	223.4	1057.5	5.0	0.0	14.4	11.5	0.0	42.4	15.0	182.9	11.2	1624.8
Mt. Sinai	487.5	1.7	0.0	0.0	0.0	6.2	0.0	4.5	0.0	5.0	1.2	3.3	509.5
Pedric CB	235.9	45.7	0.2	0.0	0.0	15.3	3.4	11.4	0.0	5.5	32.2	8.4	357.9
Phillips Road PCB	39.2	91.0	64.1	7.5	0.1	148.6	0.0	18.8	0.0	8.9	45.3	9.2	432.7
Piedmont	89.9	193.1	6.6	53.2	9.0	141.3	0.2	0.0	0.0	0.0	115.9	1.3	610.6
Piney Z	43.3	9.5	1.2	0.0	0.0	50.4	0.0	0.0	0.0	0.0	339.2	0.0	443.5
Roberts Pond	1927.3	91.8	7.2	8.7	5.3	47.2	1.9	0.0	0.0	20.8	0.0	114.2	2224.4
Royal Oaks Creek	71.8	573.6	3.8	5.4	0.0	9.4	0.0	8.3	0.0	0.0	63.4	11.6	747.1
Smith 1 CB	64.8	132.7	1.3	0.0	0.0	30.8	0.0	0.0	0.0	2.3	98.7	0.0	335.2
Smith 2 CB	110.9	48.4	1.2	1.5	0.9	9.2	0.3	0.0	0.0	0.0	0.0	1.8	174.2
Smith 3 CB	44.1	33.0	8.4	1.4	1.0	4.1	0.3	0.0	0.0	0.0	70.6	0.0	163.0
Smith 4 CB	93.2	12.0	1.5	1.8	1.1	3.4	0.4	0.0	0.0	0.0	48.3	2.7	164.3
Southwood Plantation CB	43.1	0.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	3.9	56.3	0.0	104.9
St. Peters CB	8.1	7.4	9.9	0.0	0.0	5.8	0.0	0.0	0.0	0.4	3.8	0.0	35.3
Upper Lafayette	297.0	29.6	327.9	0.0	29.7	28.6	25.1	15.5	0.0	0.0	855.1	3.6	1612.3
Vedura II	279.8	90.8	0.2	0.0	23.5	12.6	0.0	24.1	0.0	7.0	596.3	10.3	1044.7
Waverly	74.7	209.7	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	72.0	4.0	365.9
Welaunee CB	124.4	81.1	795.2	0.0	0.2	22.0	0.0	0.0	42.5	14.1	139.9	36.9	1256.4
Witfield Plantation PCB	83.7	199.8	55.6	8.7	0.0	0.0	0.0	0.0	23.0	0.0	103.7	22.4	497.0
Total:	**17643.9**	**8746.2**	**6258.0**	**1059.3**	**644.6**	**2178.5**	**1277.6**	**528.6**	**397.2**	**413.3**	**10833.8**	**1416.3**	**51397.2**
Percent of Total:	**34.3**	**17.0**	**12.2**	**2.1**	**1.3**	**4.2**	**2.5**	**1.0**	**0.8**	**0.8**	**21.1**	**2.8**	**100.0**

TABLE 6-4

CHANGES IN LAND USE CHARACTERISTICS UNDER FUTURE CONDITIONS

LAND USE	EXISTING		FUTURE		CHANGE	
	AREA (ac)	PERCENT (%)	AREA (ac)	PERCENT (%)	AREA (ac)	PERCENT (%)
Low Density Residential	12,562	24.4	17,644	4.3	5,082	40.5
Medium Density Residential	7,118	13.8	8,746	17.0	1,628	22.9
High Density Residential	844	1.6	6,258	12.2	5,414	64.1
Multi-Family Residential	1,000	1.9	1,059	2.1	59	5.9
High-Intensity Commercial	609	1.2	645	1.3	36	5.9
Low-Intensity Commercial	1,974	3.8	2,179	4.2	205	10.4
Industrial	222	0.4	1,278	2.5	1,056	476
Highway / Federal HSG=A	529	1.0	529	1.0	0	0.0
Highway / Interstate	397	0.8	397	0.8	0	0.0
Highway / Major	413	0.8	413	0.8	0	0.0
Open Space	24,315	47.3	10,834	21.1	-13,481	- 55.4
Open Water/Lake	1,416	2.8	1,416	2.8	0	0.0
TOTAL	**51,397**	**100**	**51,433**	**100**	**0**	**0**

TABLE 6-5

PERCENT IMPERVIOUS AND DCIA ASSUMPTIONS FOR EXISTING AND FUTURE CONDITIONS

LAND USE	EXISTING CONDITIONS		FUTURE CONDITIONS	
	IMPERVIOUS AREA (%)	DCIA[1] (%)	IMPERVIOUS AREA (%)	DCIA[1] (%)
Low-Density Residential	11.4	2.9	11.4	5
Medium-Density Residential	26.3	10.5	30	60
High-Density Residential	38.8	19.4	60	75
Multi-Family Residential	50	37.5	75	75
High-Intensity Commercial	85	72.3	85	90
Low-Intensity Commercial	61	45.7	65	80
Industrial	50	37.5	50	50
Highway / Federal	60	45	60	45
Highway / Interstate	40	20	40	20
Highway / Major	62.5	46.9	62.5	46.9
Recreational / Open Space	1.8	0.5	1.8	0.5

1. Directly connected impervious area expressed as a percentage of impervious area

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Estimates of impervious area and DCIA under future conditions are also provided in Table 6-4. Estimates for these parameters are based upon typical development for each of the land use categories recently constructed in the Tallahassee area. The most notable changes under the future conditions is the substantial increase in DCIA allotted for most land use categories. These increases are largely due to the fact that new development typically has well defined drainage collection and conveyance systems which increase the effective DCIA. No changes in impervious area or DCIA are included for any of the three listed highway land use categories since no additional areas are proposed under these categories for future conditions. No alteration to the assumptions for recreational/open space are proposed for future conditions since it is assumed that future development under this category will be similar to existing development.

This analysis assumes that future development will be constructed with stormwater management systems which will provide a predictable reduction in both runoff volume and mass loadings of evaluated nutrients and pollutants. It is assumed that new development constructed under the categories of medium-density residential, high-density residential, multi-family residential, high-intensity commercial, low-intensity commercial, and industrial will have stormwater management systems constructed according to existing Leon County and City of Tallahassee criteria. It is also assumed that low-density residential land use will not be constructed with stormwater management systems, since this land use is typically exempt from stormwater management criteria.

A summary of assumed additional stormwater treatment provided under future conditions is given in Table 6-6. The relative proportion of the various types of stormwater management systems under future conditions are assumed to be similar to the proportion and distribution of stormwater management systems utilized under current conditions. The primary types of stormwater management systems assumed for future development are dry detention, dry detention with filtration, dry retention, and wet detention. However, these ratios may become altered under future conditions since dry detention and dry detention with filtration are becoming increasingly less popular with regulatory agencies and may be phased out in the foreseeable future.

TABLE 6-6

SUMMARY OF ADDITIONAL STORMWATER TREATMENT PROVIDED IN LAKE LAFAYETTE SUB-BASINS UNDER FUTURE CONDITIONS

BASIN NAME	ADDITIONAL AREA WITH STORMWATER TREATMENT (acres)				
	Dry Detention	Dry Detention w/ filtration	Dry Retention (0.5 inch runoff)	Wet Detention	Total
Alford Arm	0.7	110.7	30.9	78.8	442.2
Betton Woods	8.7	547.1	170.2	179.2	1810.5
Buck Lake CB	0.2	10.0	12.0	26.1	96.5
Capital Medical Center PCB	0.9	62.6	17.8	24.1	210.8
Celebration Baptist Church CB	0.0	0.1	12.5	0.2	25.5
Desoto Lakes	2.5	162.1	68.5	194.4	855.0
East 27 CB	0.1	5.5	2.3	6.5	28.8
East Park Avenue	24.4	663.4	146.6	113.3	1895.4
East Spring Church	2.7	176.4	74.6	305.0	1117.4
Federal Correctional Institution CB	0.0	2.1	2.0	2.6	13.5
Foley Drive CB	0.0	2.7	1.1	5.9	19.4
Gilbert Pond	1.0	64.8	27.4	415.6	1017.6
Goose Pond	6.3	788.3	307.6	305.6	2815.5
Harriman Circle PCB	0.3	12.3	5.4	7.1	50.1
1-10/90	11.6	759.6	321.2	1452.2	5089.4
Killarney Plaza PCB	0.0	10.1	1.0	0.1	22.5
Lafayette Oaks CB	0.0	0.0	0.0	19.6	39.3
Lake Ella PCB	0.0	19.8	1.5	142.6	327.7
Lake Heritage	0.0	0.0	0.0	103.9	207.7
Lake Kanturk	0.2	13.1	5.5	37.1	111.7
Lake Killarney	0.3	53.9	9.1	104.0	334.6
Lake Kinsale	0.5	29.1	11.5	10.1	102.4
Lake McBride	2.1	149.1	60.1	189.3	801.1
Lake Saratoga	0.5	32.0	13.5	83.0	257.9
Lake Sheelin PCB	0.0	0.0	0.0	56.4	112.8
Lake Tom John	1.9	127.5	44.9	291.8	932.3
Lincoln High	1.8	185.8	43.8	94.2	651.2
Lower Kanturk	2.7	175.3	74.1	225.4	954.9
Lower Lafayette	0.7	39.3	16.7	196.6	506.5
Martinez	12.4	813.4	344.0	1264.3	4868.1
Maylor CB	0.0	2.4	9.0	9.7	42.3
McCord Park	1.8	80.1	38.6	147.5	535.9
Melody Hills PCB	0.8	17.7	79.6	23.3	242.6
Miles	6.0	395.0	167.0	528.9	2193.9
Millstone Creek	4.8	391.5	302.2	613.1	2623.3
Mom and Dads CB	2.3	151.4	64.0	454.4	1344.3
Moore Pond CB	0.8	52.2	281.5	87.5	844.1
Mt Hornbem	6.8	556.7	182.1	601.1	2693.4
Mt Sinai	1.9	125.6	53.1	174.5	710.4
Pedric CB	0.0	0.0	0.0	33.0	66.0
Phillips Road PCB	0.0	33.3	1.1	7.4	83.6
Piedmont	7.5	181.9	57.4	76.1	645.7
Piney Z	0.1	100.4	1.6	2.2	208.6
Roberts Pond	4.3	281.8	119.2	338.0	1486.6
Royal Oaks Creek	0.7	117.6	24.0	67.3	419.4
Smith 1 CB	0.5	29.0	12.4	74.5	232.8
Smith 2 CB	0.4	25.3	48.9	97.7	344.7
Smith 3 CB	0.2	41.9	5.6	44.6	184.7
Smith 4 CB	0.2	15.8	6.7	90.6	226.6
Southwood Plantation CB	0.0	0.0	0.0	0.0	0.0
St. Peters CB	0.2	11.3	10.5	9.4	63.0
Upper Lafayette	2.2	397.0	77.2	277.0	1506.9
Vedura II	0.0	0.0	0.0	10.2	20.4
Waverly	0.6	24.7	16.5	48.5	180.6
Welaunee CB	4.7	309.5	130.9	431.7	1753.6
Witfield Plantation PCB	0.7	165.7	89.4	39.4	590.4
Total	**130.4**	**8541.2**	**3612.1**	**10242.8**	**45053.8**

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The assumed additional stormwater treatment provided under future conditions (summarized in Table 6-6) is in addition to the existing areas treated by various stormwater treatment systems (summarized in Table 5-10). Based upon the information provided in Table 6-6, the most popular stormwater treatment system under future conditions will be wet detention, followed by dry detention and dry retention.

The "do nothing" alternative is evaluated based upon estimates of runoff volumes and pollutant loadings under current and future conditions using the historical rainfall frequency distribution for the Tallahassee area summarized in Table 5-8. As discussed in Section 5, this frequency distribution provides a summary of typical annual rainfall events in the Tallahassee area based upon a review of individual rainfall events occurring over the period from 1959-1995. This rainfall distribution is thought to reflect "average" rainfall conditions in the Tallahassee area based upon an annual average rainfall of 66.2 inches per year and is the same rainfall distribution used by ERD during the Bradfordville Stormwater Study. The rainfall distribution measured in the Lake Lafayette basin from July 2003-June 2004 was not utilized for this comparison since the rainfall characteristics measured during the monitoring program are not reflective of long-term historical average rainfall conditions. Therefore, the term "current" is used to reflect calculations based on average rainfall conditions, while the term "existing" refers to the conditions measured during the 12-month monitoring program from July 2003-June 2004.

The LLNSLMM model relies upon volumetric and mass loading attenuation factors for each of the identified sub-basin areas to account for attenuation of both runoff volume and mass loadings within the sub-basins and conveyance systems prior to reaching Lake Lafayette. Since attenuation of pollutants is primarily a function of residence time, it is anticipated that reductions in the assumed attenuation factors for the various sub-basins may occur under future conditions, compared with current conditions, as a result of anticipated increases in generated runoff volume and corresponding decreases in residence time for runoff before reaching Lake Lafayette.

The LLNSLMM model was used to provide estimates of runoff volumes and pollutant loadings under current conditions, based upon the historical rainfall frequency distribution for the Tallahassee area summarized in Table 5-8 using the same model input data used to evaluate "existing" conditions (July 2003-June 2004). The runoff volumes and pollutant loadings generated during this analysis for current conditions are used as a comparison for future conditions which are also calculated using the historical rainfall frequency distribution summarized in Table 5-8. The current conditions model was run using the hydrologic model calibration and retention factors summarized in Table 5-12 and the calibration factors for nutrient/pollutant attenuation summarized in Table 5-14. This current conditions analysis is used as the basis for evaluating changes in loadings and anticipated water quality characteristics for all future conditions scenarios.

The LLNSLMM model summarized in Section 5 was used to estimate runoff volumes generated within the Lake Lafayette watershed under future conditions based upon the future land use characteristics summarized in Table 6-3, the assumed future hydrologic characteristics summarized in Table 6-5, and the historical rainfall frequency distribution summarized in Table 5-8. The ratio of generated runoff volumes under current and future conditions was then calculated for each sub-basin area discharging to Lake Lafayette. Since volumetric and pollutant attenuation is a function of runoff volume and residence time, changes in volumetric and pollutant attenuations under future conditions would be related to the ratio of the runoff volumes generated under current and future conditions.

The hydrologic model calibration and retention factors (summarized in Table 5-12) and the nutrient/pollutant factors (summarized in Table 5-14) were adjusted under future conditions to reflect the anticipated decreases in volumetric and pollutant attenuation according to the following relationship:

$$\textit{Future Attenuation Factor } (AF_F) = [1 - (1 - AF_E * Ratio)]$$

where:

AF_F	=	attenuation factor under future conditions
AF_E	=	attenuation factor under existing conditions
Ratio	=	Runoff Volume (current) divided by Runoff Volume (future)

The calculated future attenuation factors were then input into the LLNSLMM model to predict volumetric and pollutant loadings under future conditions. A complete listing of calculated attenuation factors under future conditions for each of the Lake Lafayette sub-basins is given in Table 6-7.

TABLE 6-7

CALCULATED DELIVERY RATIOS FOR FUTURE CONDITIONS IN THE LAKE LAFAYETTE WATERSHED

BASIN	DELIVERY RATIOS FOR FUTURE CONDITIONS						
	VOLUME	TOTAL N	TOTAL P	BOD	TSS	Cu	Zn
Alford Arm	1.041	1.041	1.041	1.041	1.041	1.041	1.041
Betton Woods	0.553	0.239	0.396	0.345	0.499	0.589	0.225
Buck Lake CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital Medical Center PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Celebration Baptist Church CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Desoto Lakes	0.087	0.075	0.082	0.301	0.072	0.173	0.061
East 27 CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
East Park Avenue	0.537	0.232	0.385	0.335	0.485	0.573	0.219
East Spring Church	1.566	1.566	1.566	1.566	1.566	1.566	1.566
Federal Correctional Institution CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Foley Drive CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gilbert Pond	0.087	0.075	0.082	0.302	0.072	0.174	0.062
Goose Pond	0.554	0.239	0.397	0.346	0.501	0.591	0.226
Harriman Circle PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
I-10/90	0.099	0.086	0.094	0.344	0.082	0.198	0.070
Killarney Plaza PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Lafayette Oaks CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lake Ella PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Lake Heritage	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lake Kanturk	0.086	0.074	0.081	0.297	0.071	0.171	0.061
Lake Killarney	0.086	0.074	0.081	0.297	0.071	0.171	0.061
Lake Kinsale	0.086	0.074	0.081	0.297	0.071	0.171	0.061
Lake McBride	0.088	0.076	0.083	0.304	0.073	0.175	0.062
Lake Saratoga	0.086	0.075	0.081	0.298	0.071	0.172	0.061
Lake Sheelin PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Lake Tom John	0.093	0.081	0.088	0.324	0.078	0.187	0.066
Lincoln High	0.995	1.073	2.638	0.987	5.221	1.446	0.356
Lower Kanturk	0.121	0.105	0.115	0.421	0.101	0.242	0.086
Lower Lafayette	1.033	1.033	1.033	1.033	1.033	1.033	1.033
Martinez	0.086	0.075	0.081	0.299	0.072	0.172	0.061
Maylor CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
McCord Park	0.541	0.234	0.388	0.338	0.489	0.577	0.220
Melody Hills PCB	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Miles	0.094	0.082	0.089	0.328	0.079	0.189	0.067
Millstone Creek	0.092	0.080	0.088	0.321	0.077	0.185	0.066
Mom and Dads CB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Moore Pond CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mt Hornbem	0.109	0.095	0.103	0.380	0.091	0.218	0.077
Mt Sinai	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Pedric CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Phillips Road PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Piedmont	0.573	0.248	0.411	0.358	0.518	0.611	0.233
Piney Z	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Roberts Pond	0.086	0.075	0.082	0.300	0.072	0.173	0.061
Royal Oaks Creek	0.086	0.074	0.081	0.297	0.071	0.171	0.061
Smith 1 CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Smith 2 CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Smith 3 CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Smith 4 CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Southwood Plantation CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
St. Peters CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Upper Lafayette	1.086	1.086	1.086	1.086	1.086	1.086	1.086
Vedura II	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Waverly	0.537	0.232	0.385	0.335	0.485	0.573	0.219
Welaunee CB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Witfield Plantation PCB	0.010	0.010	0.010	0.010	0.010	0.010	0.010

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A summary of calculated hydrologic and pollutant loadings under current and future conditions within the Lake Lafayette watershed is given in Table 6-8 based on the historical rainfall frequency distribution. Hydrologic and pollutant inputs are included for each of the sources evaluated in the existing conditions analysis summarized in Sections 3 and 4. Estimated inputs from bulk precipitation are assumed to be identical under current and future conditions, while inflows from tributaries and direct runoff increase in most cases.

A graphical comparison of current and future average annual volumetric inputs to the four compartments of Lake Lafayette is given in Figure 6-1. Increases in volumetric inputs under future conditions are anticipated in Upper Lake Lafayette, Alford Arm, and Lower Lake Lafayette. No additional increases in volumetric loadings are predicted for Lake Piney Z since no additional development is anticipated within this sub-basin under future conditions. Under future conditions, volumetric inputs to Upper Lake Lafayette are expected to increase by approximately 5%, with a 36% increase in volumetric loading to Alford Arm and an 18% increase in volumetric loading to Lower Lake Lafayette.

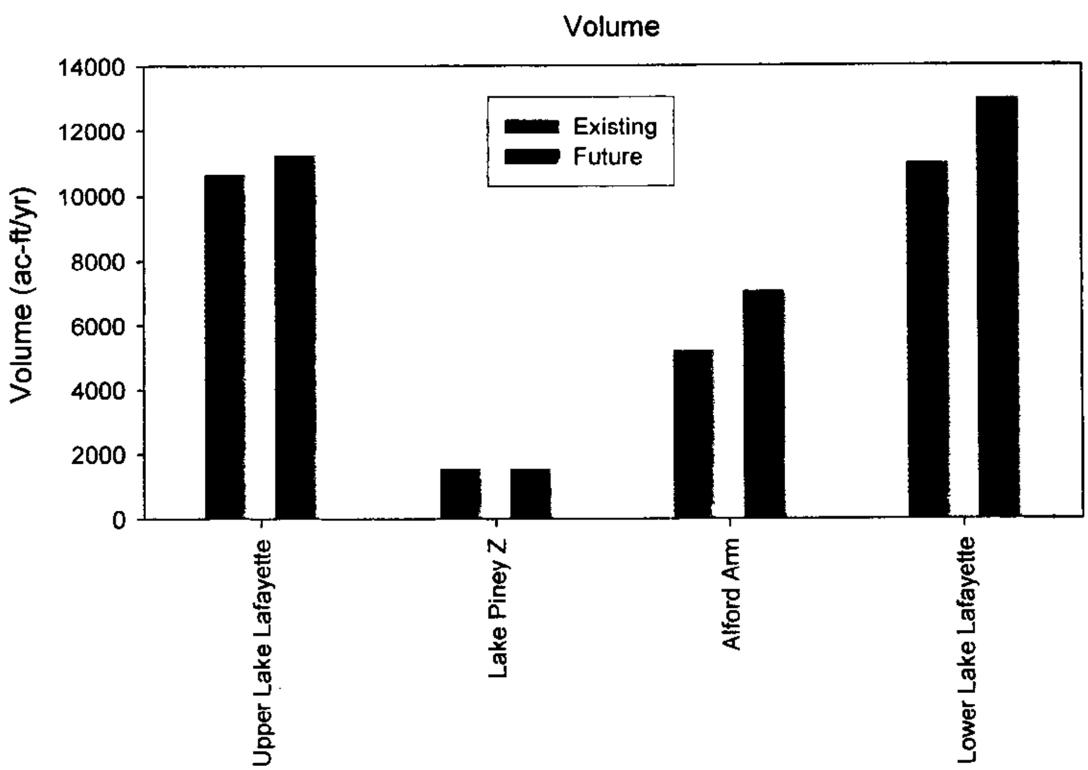

Figure 6-1. Comparison of Current and Future Average Annual Volumetric Inputs to the Four Compartments of Lake Lafayette.

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TABLE 6-8

CALCULATED HYDROLOGIC AND POLLUTANT LOADINGS UNDER CURRENT AND FUTURE CONDITIONS BASED ON AVERAGE RAINFALL CONDITIONS[1]

Upper Lake Lafayette

a. Current Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Weems Pond Tributary	5,675	3,563	845	18,824	124,417
Lafayette Creek Tributary	2,002	2,953	1,012	10,909	274,132
Direct Runoff	923	1,377	136	3,316	13,058
Bulk Precipitation	2,058	1,703	114	5,076	15,736
Total Input	**10,658**	**9,596**	**2,107**	**38,125**	**427,343**

b. Future Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Weems Pond Tributary	5,993	3,770	902	19,800	128,258
Lafayette Creek Tributary	2,012	2,932	1,023	10,671	263,516
Direct Runoff	1,176	1,904	245	4,699	19,698
Bulk Precipitation	2,058	1,703	114	5,076	15,736
Total Input	**11,239**	**10,309**	**2,272**	**40,246**	**427,209**

Lake Piney Z

a. Current Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Direct Runoff	267	357	30	1,070	3,441
Bulk Precipitation	1,274	1,054	71	3,142	9,741
Total Input Mass	**1,541**	**1,411**	**101**	**4,212**	**13,182**

b. Future Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Direct Runoff	267	357	30	1,070	3,441
Bulk Precipitation	1,274	1,054	71	3,142	9,741
Total Input Mass	**1,541**	**1,411**	**101**	**4,212**	**13,182**

TABLE 6-8 -- CONTINUED

CALCULATED HYDROLOGIC AND POLLUTANT LOADINGS UNDER CURRENT AND FUTURE CONDITIONS BASED ON AVERAGE RAINFALL CONDITIONS[1]

Alford Arm

a. Current Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Alford Arm Tributary	1,422	1,026	129	5,899	15,368
Direct Runoff	1,774	2,347	433	4,514	40,985
Bulk Precipitation	2,025	1,676	112	4,995	15,484
Total Input	**5,221**	**5,049**	**674**	**15,408**	**71,837**

b. Future Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Alford Arm Tributary	1,778	1,507	260	11,966	21,527
Direct Runoff	3,271	3,424	626	15,221	61,671
Bulk Precipitation	2,025	1,676	112	4,995	15,484
Total Input	**7,083**	**6,607**	**998**	**32,182**	**98,682**

Lower Lake Lafayette

a. Current Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Inflow from Alford Arm	2,104	927	97	3,873	10,029
Direct Runoff	3,228	4,470	612	9,782	91,603
Bulk Precipitation	5,666	4,689	314	13,975	43,324
Total Input Mass	**10,998**	**10,086**	**1,023**	**27,630**	**144,956**

b. Future Conditions

SOURCE	VOLUME (ac-ft)	TOTAL N (kg/yr)	TOTAL P (kg/yr)	BOD (kg/yr)	TSS (kg/yr)
Inflow from Alford Arm	3,966	1,686	199	11,242	19,144
Direct Runoff	3,361	4,544	672	10,678	89,467
Bulk Precipitation	5,666	4,689	314	13,975	43,324
Total Input Mass	**12,993**	**10,919**	**1,186**	**35,896**	**151,935**

1. Annual average rainfall of 66.2 inches/year

A graphical comparison of current and future nutrient and pollutant inputs to Lake Lafayette is given in Figure 6-2. Under future conditions, nitrogen inputs to Upper Lake Lafayette are expected to increase by approximately 7%, with a 31% increase in nitrogen loadings to Alford Arm and an 8% increase in nitrogen loadings to Lower Lake Lafayette. Phosphorus loadings to Upper Lake Lafayette are expected to increase by approximately 8%, with a 48% increase in phosphorus loadings to Alford Arm and a 16% increase in phosphorus loadings to Lower Lake Lafayette.

Estimated loadings of BOD to Upper Lake Lafayette are projected to increase approximately 6%, with a 109% increase in BOD loadings to Alford Arm and a 30% increase in BOD loadings to Lower Lake Lafayette. Annual loadings of suspended solids to Upper Lake Lafayette are expected to be similar under current and future conditions. However, TSS loadings to Alford Arm are projected to increase by approximately 37%, with a 5% increase in Lower Lake Lafayette. No changes to current loadings of total nitrogen, total phosphorus, TSS, or BOD are anticipated in Lake Piney Z since no additional development is projected in sub-basin areas discharging to this compartment.

A comparison of estimated total and areal loadings of phosphorus to Lake Lafayette under current and future conditions is given in Table 6-9. Under future conditions, both total annual and areal loadings of phosphorus to Upper Lake Lafayette, Alford Arm, and Lower Lake Lafayette are projected to increase as new development occurs within the Lake Lafayette watershed. These predicted increases in phosphorus loadings occur in spite of construction and implementation of stormwater management systems required for new development. The most dramatic increases in phosphorus loadings will occur in Alford Arm, with a projected 49% increase in areal loading under future conditions. The increases in total loadings and areal loadings will provide additional phosphorus sources for stimulation of primary productivity in the form of both aquatic macrophytes and pelagic algae.

A comparison of estimated total and areal loadings of nitrogen to the four compartments of Lake Lafayette under current and future conditions is given in Table 6-10. Under future conditions, both total loadings and areal loadings of nitrogen are projected to increase in Upper Lake Lafayette and Alford Arm. Areal loadings of total nitrogen to Upper Lake Lafayette and Alford Arm exceed the dangerous permissible loading level for nitrogen under both current and future conditions.

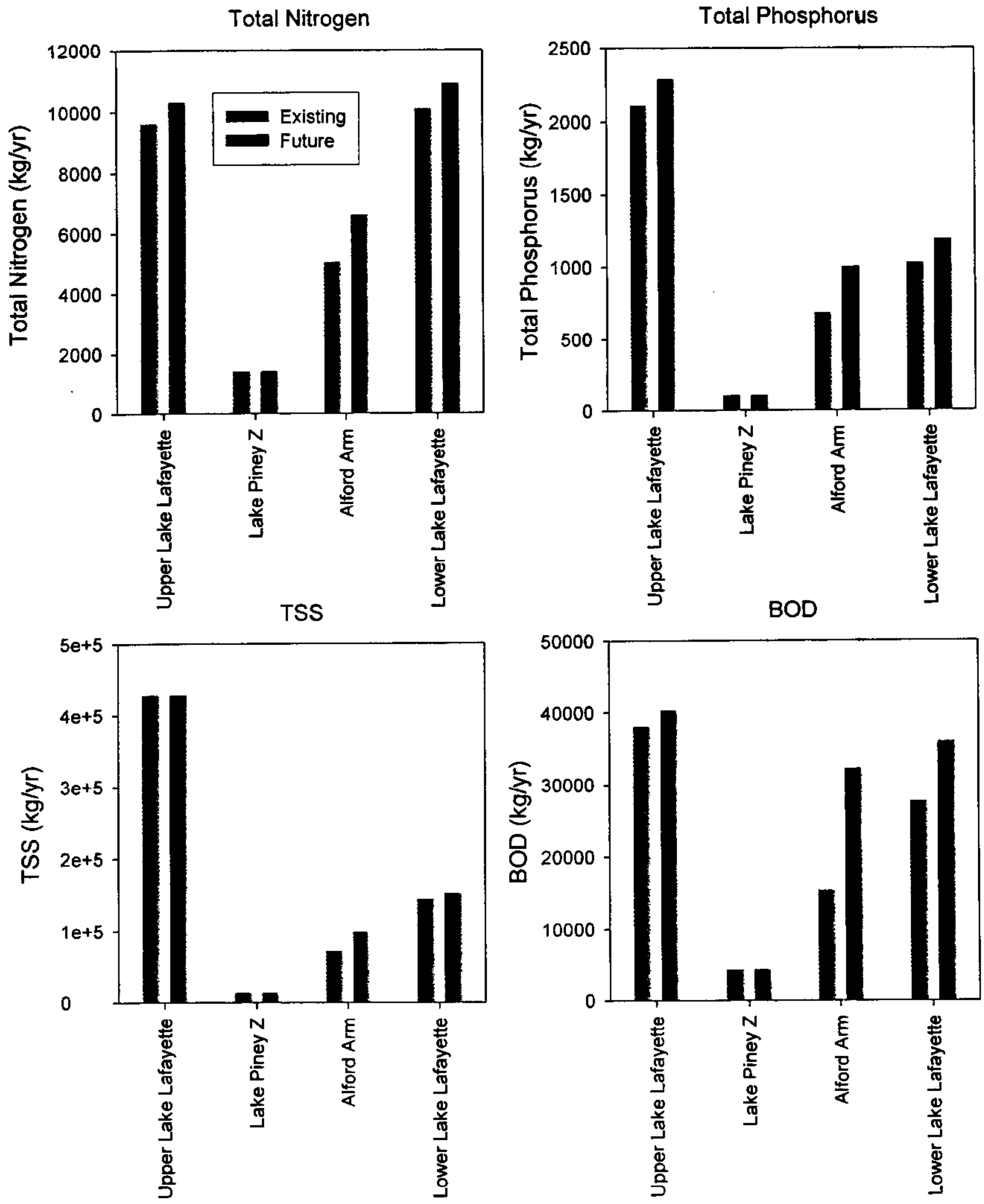

Figure 6-2. Comparison of Annual Mass Loadings for Current and Future Conditions of Total Nitrogen, Total Phosphorus, TSS, and BOD Based on Average Rainfall Conditions.

TABLE 6-9

COMPARISON OF ESTIMATED TOTAL AND AREAL LOADINGS OF PHOSPHORUS TO LAKE LAFAYETTE UNDER CURRENT AND FUTURE CONDITIONS BASED ON AVERAGE RAINFALL CONDITIONS

COMPARTMENT	LAKE AREA (acres)	CURRENT LOADING		FUTURE LOADING	
		kg/yr	g/m^2-yr	kg/yr	g/m^2-yr
Upper Lake Lafayette	373	2,107	1.40	2,272	1.50
Lake Piney Z	231	101	0.11	101	0.11
Alford Arm	367	674	0.45	998	0.67
Lower Lake Lafayette	1,027	1,023	0.25	1,186	0.29

<u>Permissible Loading Levels (Vollenweider, 1968) for Lakes up to 15 m Deep:</u>

Phosphorus: a. Permissible: < 0.1 g/m^2-yr
b. Dangerous: > 0.2 g/m^2-yr

TABLE 6-10

COMPARISON OF ESTIMATED TOTAL AND AREAL LOADINGS OF NITROGEN TO LAKE LAFAYETTE UNDER CURRENT AND FUTURE CONDITIONS BASED ON AVERAGE RAINFALL CONDITIONS

COMPARTMENT	LAKE AREA (acres)	CURRENT LOADING		FUTURE LOADING	
		kg/yr	g/m^2-yr	kg/yr	g/m^2-yr
Upper Lake Lafayette	373	9,596	6.35	10,309	6.83
Lake Piney Z	231	1,411	1.51	1,411	1.51
Alford Arm	367	5,049	3.40	6,607	4.45
Lower Lake Lafayette	1,027	10,086	2.43	10,919	2.63

<u>Permissible Loading Levels (Vollenweider, 1968) for Lakes up to 15 m Deep:</u>

Nitrogen: a. Permissible: < 1.5 g/m^2-yr
b. Dangerous: > 3.0 g/m^2-yr

Under the "do nothing" scenario, increases in mass loadings of total nitrogen, total phosphorus, TSS, and BOD are anticipated in Upper Lake Lafayette, Alford Arm, and Lower Lake Lafayette in spite of the stormwater management systems which will be constructed for new development. Increases in inputs of other development-related constituents such as heavy metals, organic compounds and microbiological parameters can also be expected. Existing problems with overgrowth of aquatic vegetation can be expected to get worse, and a larger volume of water will ultimately discharge into the sink areas in Upper Lake Lafayette, increasing the potential for contamination of the underground aquifer system.

6.3 Management Options for Upper Lake Lafayette

The evaluated management options for Upper Lake Lafayette are primarily intended to reduce the potential for contamination of the underground aquifer as a result of discharges into the various sinks as well as infiltration through the lake bottom. The evaluated options include providing vegetative treatment for inflows prior to reaching the sinks, redirecting channel flow paths into Lake Piney Z, construction of berms around the sink areas to detain runoff and baseflow inputs, and construction of stormwater treatment systems for Weems Pond and Lafayette Creek inflows. Each of these selected management options are discussed in the following sections.

6.3.1 Construct Vegetative Flow Paths for Inflows

As discussed in Section 2.2, inputs from Lafayette Creek and Weems Pond are transported into and through Upper Lake Lafayette by several natural earthen channels and impacted streams. These inflows are irregular in shape and contain little vegetation under existing conditions. Erosion within these channels is a common occurrence during significant storm events.

One potential management option is to widen the existing flow paths and provide a controlled reinforced section in place of the current unstable channel. The widened channels would have a larger cross-sectional area and a lower flow velocity for a given discharge, reducing the potential for erosion. The channel would be constructed similar to a shallow swale and would be heavily vegetated to further reduce erosion and provide additional pollutant uptake and attenuation. A typical cross-section of a vegetated flow-way is given in Figure 6-3. Common wetland vegetation species are indicated based on relative tolerance for wetted conditions, although a wide variety of potential wetland species could be used. The bottom of the channel could be reinforced with a geocell or geofabric and various types of vegetation could be planted, depending upon anticipated water depth, in various portions of the channel. This stabilized channel would substantially eliminate the existing erosive conditions as well as providing plant material for additional uptake of nutrients and other pollutants. The widened channel would also provide additional opportunity for infiltration and evapotranspiration of water prior to reaching the sink, potentially reducing the ultimate volume of water reaching the main sink area. The specific width and depth of the flow-way channels would need to be determined based upon anticipated runoff discharge rates and velocities during the selected design storm event for each tributary.

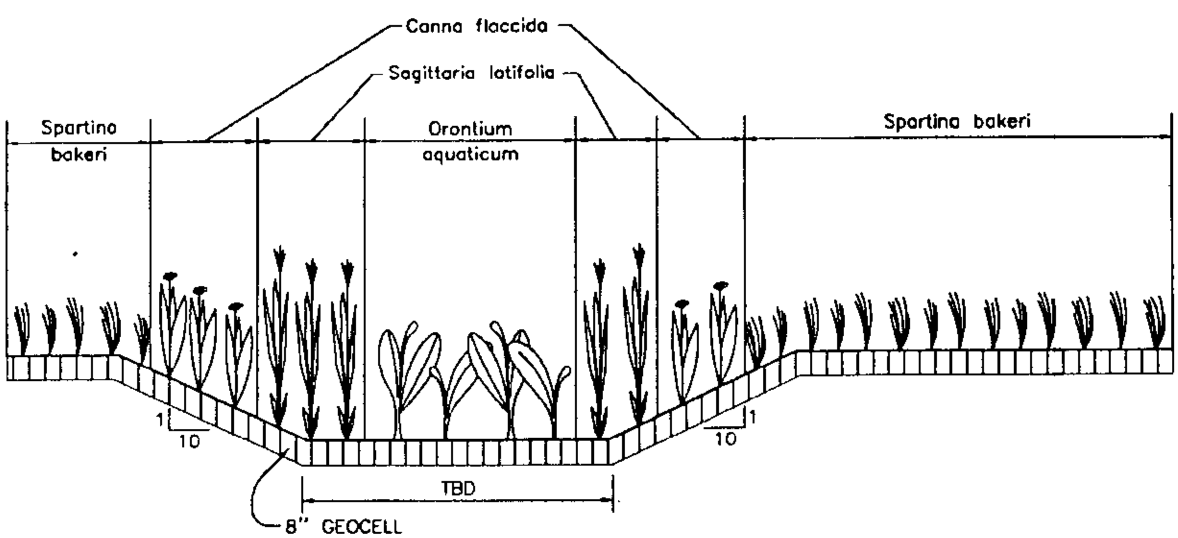

Figure 6-3. Typical Cross-Section of Vegetated Flow-Way for Inflows to Upper Lake Lafayette.

A research project on the removal effectiveness of a vegetated channel for treatment of contaminants contained in highway runoff was conducted by Harper (1988). During this project, both inflow and outflow through a vegetated channel were monitored over a period of 12 months. The length of the vegetated channel was approximately 750 ft. A summary of annual mean concentration-based removal efficiencies for highway runoff during migration through the vegetated channel is given in Table 6-11. The vegetated channel was effective in reducing concentrations of all measured constituents. Constituents with a higher particulate fraction were found to be attenuated at a more rapid rate than constituents which were primarily dissolved in nature. However, removal efficiencies ranging from 20-80% were obtained during the study.

TABLE 6-11

CONCENTRATION-BASED REMOVAL EFFICIENCIES FOR HIGHWAY RUNOFF DURING MIGRATION THROUGH A VEGETATED CHANNEL
(Harper, 1988)

CONSTITUENT	CONCENTRATION REDUCTION (%)
Total N	20
Total P	40
BOD	40
TSS	80
Cadmium	40
Copper	56
Chromium	37
Lead	50
Zinc	69

Construction of the proposed vegetated flow-ways would be expected to provide removal efficiencies for inflows into Upper Lake Lafayette from Lafayette Creek and Weems Pond, similar to those reported by Harper. The concentration-based removal efficiencies summarized in Table 6-11 would be applicable primarily to baseflow inputs and runoff inputs from relatively small rain events. The rain event which could be fully retained within the vegetated flow-ways would be somewhat lower for Lafayette Creek than Weems Pond since Lafayette Creek inflows directly into Upper Lake Lafayette while peak flows through the Weems Pond tributary receive substantial attenuation within the pond. Therefore, this alternative would be expected to be more effective for treating inflow from Weems Pond than from Lafayette Creek. However, removal efficiencies for rain events with significant velocities or for rain events which temporarily flood Upper Lake Lafayette would be substantially lower than the values indicated in Table 6-11. Therefore, exceedances of Class III criteria in water reaching the sink area can still be anticipated for heavy metals and microbiological parameters on a periodic basis.

As seen in Table 4-11, baseflow inputs from Lafayette Creek and Weems Pond contribute relatively minimal loadings of total nitrogen, total phosphorus, TSS, and BOD into Upper Lake Lafayette. As discussed previously, the vegetated flow-ways would also be capable of treating relatively small rain events which would further increase the annual volumes of water which could treated within these systems. However, larger rain events contribute the majority of runoff which enters Lake Lafayette on an annual basis. Although the proposed vegetated flow-ways would reduce erosion and turbidity associated with treatable inputs into Upper Lake Lafayette, the vegetated channels would provide uptake for a relatively small portion of the loadings entering Upper Lake Lafayette. The most significant loadings originate from stormwater runoff during larger rain events, much of which would exceed the capacity of the vegetated flow-ways and receive minimal treatment.

Estimates of the annual mass removal of total nitrogen and total phosphorus achieved within the proposed vegetated flow-ways in Upper Lake Lafayette were calculated based on average rainfall conditions and the calculated current and future loadings to Upper Lake Lafayette summarized in Table 6-8. For this analysis, the distribution of baseflow and stormwater loadings discharging through the Weems Pond tributary and the Lafayette Creek tributary are assumed to be similar to the proportion of baseflow and stormwater loadings measured during the 12-month monitoring period from July 2003-June 2004. During this period, baseflow contributed approximately 3.6% of the total nitrogen loadings discharging through Lafayette Creek and 1.8% of the total phosphorus loadings. For discharges from Weems Pond, baseflow contributed approximately 8.6% of the total nitrogen loadings and 6.2% of the total phosphorus loadings. The estimated annual loadings of total nitrogen and total phosphorus for current and future conditions, summarized in Table 6-8, were allocated into baseflow and stormwater utilizing these percentages.

For this analysis, it is assumed that the vegetated flow-ways will provide 100% attenuation and uptake for baseflow discharges entering Upper Lake Lafayette. It is further assumed that runoff events representing approximately 25% of the annual mass loadings of total nitrogen and total phosphorus can be treated within the vegetated flow-ways without flooding larger portions of Upper Lake Lafayette and substantially reducing the potential effectiveness of the vegetated flow-ways. It is also assumed that approximately 20% of the total nitrogen loadings in stormwater discharging through the proposed vegetated flow-ways will be attenuated, with approximately 40% of the total phosphorus loading removed within the flow-way. These percentages are assumed for flow-ways connected to both Lafayette Creek and Weems Pond.

A summary of estimated annual mass removal of total nitrogen in the proposed vegetated flow-ways in Upper Lake Lafayette based on average rainfall conditions is given in Table 6-12. As indicated previously, it is assumed that the vegetated flow-ways will remove 100% of the nitrogen inputs in baseflow under both current and future conditions, with 20% of the nitrogen loading in stormwater which discharges through the flow-ways. No attenuation is assumed for direct runoff or bulk precipitation as a result of the proposed flow-way systems. Overall, the proposed vegetated flow-ways will provide a 7% reduction in annual mass loadings of total nitrogen under both current and future conditions.

Estimated annual mass removals of total phosphorus in the proposed vegetated flow-way are summarized in Table 6-13 based upon the same methodology previously discussed for total phosphorus. It is assumed that the proposed vegetated flow-ways will remove 100% of the baseflow inputs and approximately 40% of the total phosphorus inputs from stormwater runoff. On an annual basis, the proposed vegetated flow-ways will remove approximately 12% of the total phosphorus loadings to Lake Lafayette under current conditions and approximately 11% under future conditions.

TABLE 6-12

ESTIMATED ANNUAL MASS REMOVAL OF TOTAL NITROGEN IN THE VEGETATED FLOW-WAYS BASED ON AVERAGE RAINFALL CONDITIONS

SOURCE	CURRENT CONDITIONS		FUTURE CONDITIONS	
	ESTIMATED LOAD (kg/yr)	UPTAKE BY FLOW-WAY[1] (kg/yr)	ESTIMATED LOAD (kg/yr)	UPTAKE BY FLOW-WAY[1] (kg/yr)
Lafayette Creek				
Baseflow	106	106	103	103
Stormwater	2847	142	2829	141
Weems Pond				
Baseflow	306	306	324	324
Stormwater	3257	163	3446	172
Direct Runoff	1377	0	1904	0
Bulk Precipitation	1703	0	1703	0
TOTALS:	**9596**	**717**	**10,309**	**740**
Overall Mass Removal (%)		7		7

1. Assumes that 25% of annual stormwater load could be redirected to Lake Piney Z, with a removal of 20% of total nitrogen during travel through vegetated flow-way

TABLE 6-13

ESTIMATED ANNUAL MASS REMOVAL OF TOTAL PHOSPHORUS IN THE VEGETATED FLOW-WAY BASED ON AVERAGE RAINFALL CONDITIONS

SOURCE	CURRENT CONDITIONS		FUTURE CONDITIONS	
	ESTIMATED LOAD (kg/yr)	UPTAKE BY FLOW-WAY[1] (kg/yr)	ESTIMATED LOAD (kg/yr)	UPTAKE BY FLOW-WAY[1] (kg/yr)
Lafayette Creek				
Baseflow	18	18	18	18
Stormwater	994	99	1005	101
Weems Pond				
Baseflow	52	52	56	56
Stormwater	793	79	846	85
Direct Runoff	136	0	245	0
Bulk Precipitation	114	0	114	0
TOTALS:	**2107**	**248**	**2272**	**260**
Overall Mass Removal (%)		12		11

1. Assumes that 25% of annual stormwater load could be redirected to Lake Piney Z, with a removal of 40% of total phosphorus during travel through vegetated flow-way

As indicated by the above analysis, the proposed vegetated flow-ways will provide relatively minimal reductions in annual mass loadings of total nitrogen or total phosphorus discharging into the sink areas in Upper Lake Lafayette. In fact, the portion of the removal efficiencies attributed to attenuation of baseflow inputs is already achieved with in Upper Lake Lafayette by infiltration into the porous lake bottom without construction of the vegetated flow-way. Perhaps the most useful aspect of the vegetated flow-way concept is the reduction in erosion and generation of turbidity which apparently occurs within the existing earthen channels under current conditions.

The estimated annual mass removal for total nitrogen and total phosphorus summarized in Tables 6-12 and 6-13 reflect estimated annual mass load reductions by surface flow only. This analysis assumes that uptake of nitrogen and phosphorus occurs through the combined processes of infiltration, entrapment of particulate matter, and uptake by vegetation. However, nitrogen species, particularly NO_x, are relatively mobile during migration through soils, and a large percentage of these species may ultimately enter groundwater beneath Upper Lake Lafayette, reducing the effective removal efficiencies to values somewhat lower than those summarized at the bottom of Table 6-12. Phosphorus species tend to be much less mobile than nitrogen species, and the overall anticipated removals for total phosphorus within the proposed vegetated flow-ways will be similar to the values summarized at the bottom of Table 6-13.

Although certain nitrogen species may enter groundwater as a result of the proposed vegetated flow-ways, infiltration through the soil layers will be very effective in removing bacteria, heavy metals, and organic contaminants. Therefore, it appears that the proposed vegetated flow-ways represent a relatively inexpensive method of reducing direct loadings to the sinks, particularly for phosphorus, heavy metals, bacteria, and organics, although the overall mass reductions will be relatively low.

6.3.2 Redirect Flow Channels to Lake Piney Z

A second option for reducing the potential for contamination of the sink areas is to redirect the flow paths of the existing channels from Lafayette Creek and Weems Pond into Lake Piney Z, bypassing the existing discharge into the primary Lafayette sink. This alternative would also involve improvement of the hydraulic connection between Upper Lake Lafayette and Lake Piney Z to allow the additional water transfer.

Redirection and reconstruction of the flow paths from Lafayette Creek and Weems Pond could be performed using shallow vegetated channels similar to that depicted in Figure 6-3. The channels could also be constructed to intercept portions of the direct runoff which discharges into Upper Lake Lafayette from watershed areas immediately adjacent to the lake. These channels would provide complete attenuation of virtually all baseflow inputs since little or no baseflow currently reaches the primary Lafayette sink under existing conditions. Since the new channels would be substantially longer than the existing channels, additional opportunities for infiltration and pollutant uptake would occur along the flow path prior to reaching Lake Piney Z.

During migration through the vegetated channel, the additional runoff loadings to Lake Piney Z will be attenuated, with removal efficiencies similar to the concentration-based removal efficiencies summarized in Table 6-11. Therefore, the assumed annual mass loadings directed toward Lake Piney Z (25% of stormwater from Lafayette Creek and Weems Pond and 25% of direct runoff) are further attenuated based upon the concentration reduction factors presented in Table 6-11. The resulting values represent the estimated annual loadings which will be diverted to Lake Piney Z.

An evaluation of the potential mass of total nitrogen and total phosphorus which could be diverted into Lake Piney Z was performed using the estimated annual mass budgets for total nitrogen and total phosphorus based on average rainfall conditions, summarized in Table 6-8. For this analysis, the percentage of total annual loadings attributed to baseflow and stormwater are assumed to be similar to the percentages reflected in the estimated annual mass budgets developed for the period from July 2003-June 2004. This analysis assumes that approximately 25% of the estimated annual mass loadings of total nitrogen and total phosphorus in stormwater inputs from Lafayette Creek and Weems Pond could be redirected into Lake Piney Z, along with 25% of the direct runoff loadings. During migration through the shallow vegetated channels, approximately 20% of the total nitrogen would be removed and 40% of the total phosphorus would be removed, based upon the estimated mass removals summarized in Table 6-8, with the remaining loadings discharging into Lake Piney Z.

Estimates of the annual mass transfer of total nitrogen to Lake Piney Z based on average rainfall conditions is given in Table 6-14. As indicated in the assumptions for this analysis, no transfer of mass loadings from baseflow, or bulk precipitation is anticipated from Upper Lake

Lafayette to Lake Piney Z. Under current conditions, redirecting flow channels to Lake Piney Z would transfer approximately 1495 kg/yr of total nitrogen, with a transfer of 1636 kg/yr under future conditions. This corresponds to approximately 16% of the total nitrogen inputs to Upper Lake Lafayette under existing conditions and 16% under future conditions. As a result, redirection of the flow channels to Lake Piney Z would result in a relatively minimal impact on total nitrogen loadings in Upper Lake Lafayette.

TABLE 6-14

ESTIMATED ANNUAL MASS TRANSFER OF TOTAL NITROGEN TO LAKE PINEY Z BASED ON AVERAGE RAINFALL CONDITIONS

SOURCE	CURRENT CONDITIONS		FUTURE CONDITIONS	
	ESTIMATED LOAD (kg/yr)	INPUT TO LAKE PINEY Z[1] (kg/yr)	ESTIMATED LOAD (kg/yr)	INPUT TO LAKE PINEY Z[1] (kg/yr)
Lafayette Creek				
Baseflow	106	0	103	0
Stormwater	2847	569	2829	566
Weems Pond				
Baseflow	306	0	324	0
Stormwater	3257	651	3446	689
Direct Runoff	1377	275	1904	381
Bulk Precipitation	1703	0	1703	0
TOTALS:	**9596**	**1495**	**10,297**	**1636**
Overall Mass Removal (%)		16		16

1. Assumes that 25% of annual stormwater load could be redirected to Lake Piney Z, with a removal of 20% of total nitrogen during travel through vegetated flow-way

Estimated annual mass transfer of total phosphorus to Lake Piney Z based on average rainfall conditions is summarized in Table 6-15. Based on the methodology discussed previously, redirection of the flow paths would transfer approximately 288 kg/yr of total phosphorus under existing conditions, with a transfer of 315 kg/yr under future conditions. These values correspond to approximately 14% of the total phosphorus loading under current conditions and 14% of the total phosphorus loading to Upper Lake Lafayette under future conditions. Similar to the conclusions reached for total nitrogen, redirection of the flow channels to Lake Piney Z would have relatively minimal impact on phosphorus loadings into Upper Lake Lafayette.

TABLE 6-15

ESTIMATED ANNUAL MASS TRANSFER
OF TOTAL PHOSPHORUS TO LAKE PINEY Z
BASED ON AVERAGE RAINFALL CONDITIONS

SOURCE	CURRENT CONDITIONS		FUTURE CONDITIONS	
	ESTIMATED LOAD (kg/yr)	INPUT TO LAKE PINEY Z[1] (kg/yr)	ESTIMATED LOAD (kg/yr)	INPUT TO LAKE PINEY Z[1] (kg/yr)
Lafayette Creek				
Baseflow	18	0	18	0
Stormwater	994	149	1005	151
Weems Pond				
Baseflow	52	0	56	0
Stormwater	793	119	846	127
Direct Runoff	136	20	245	37
Bulk Precipitation	114	0	114	0
TOTALS:	**2107**	**288**	**2272**	**315**
Overall Mass Removal (%)		14		14

1. Assumes that 25% of annual stormwater load could be redirected to Lake Piney Z, with a removal of 40% of total phosphorus during travel through vegetated flow-way

A revised nutrient budget for Lake Piney Z is given in Table 6-16, based upon diversion of runoff from Upper Lake Lafayette. Diversion of runoff from Upper Lake Lafayette will introduce substantial additional nutrient loadings to Lake Piney Z. Under current conditions, total nitrogen loadings to Lake Piney Z will increase by approximately 106%, with a 285% increase in total phosphorus loadings. Under future conditions, total nitrogen loadings will increase by 116%, with a 312% increase in total phosphorus load.

A comparison of estimated total and areal loadings of nitrogen and phosphorus to Lake Piney Z with the runoff diversion option is given in Table 6-17. Diversion of runoff into Lake Piney Z will increase the areal phosphorus loading from 0.11 g/m^2-yr, near permissible levels defined by Vollenweider, to 0.4 g/m^2-yr, under both current and future conditions, exceeding the dangerous phosphorus loading levels established by Vollenweider. Similarly, nitrogen loadings will increase from 1.51 g/m^2-yr under current conditions, near the permissible loading of 1.5 g/m^2-yr, to 3.11 and 3.26 g/m^2-yr, exceeding the dangerous level for nitrogen loading. These increases in areal loadings of phosphorus and nitrogen will have substantial impacts on water quality characteristics in Lake Piney Z, resulting in stimulation of existing aquatic vegetation and algal growth within the lake.

TABLE 6-16

REVISED NUTRIENT BUDGET FOR LAKE PINEY Z BASED ON DIVERSION OF RUNOFF FROM UPPER LAKE LAFAYETTE

SOURCE	CURRENT CONDITIONS		FUTURE CONDITIONS	
	Total N (kg/yr)	Total P (kg/yr)	Total N (kg/yr)	Total P (kg/yr)
Direct Runoff	357	30	357	30
Bulk Precipitation	1054	71	1054	71
Existing Totals:	**1411**	**101**	**1411**	**101**
Inflow from Upper Lake Lafayette	1495	288	1636	315
New Totals:	**2906**	**389**	**3047**	**416**
Percent Increase (%)	106	285	116	312

TABLE 6-17

COMPARISON OF ESTIMATED TOTAL AND AREAL LOADINGS OF NITROGEN AND PHOSPHORUS TO LAKE PINEY Z WITH RUNOFF DIVERSION OPTION

CONDITION	PHOSPHORUS LOADING		NITROGEN LOADING	
	kg/yr	g/m^2-yr	kg/yr	g/m^2-yr
Current – no diversion	101	0.11	1411	1.51
Current – with diversion	389	0.42	2906	3.11
Future – with diversion	416	0.44	3047	3.26

Permissible Loading Levels (Vollenweider, 1968) for Lakes up to 15 m Deep:

1. Phosphorus:
   a. Permissible: < 0.1 g/m^2-yr
   b. Dangerous: > 0.2 g/m^2-yr

2. Nitrogen:
   a. Permissible: < 1.5 g/m^2-yr
   b. Dangerous: > 3.0 g/m^2-yr

A factor which has not yet been addressed is the technical feasibility of transferring water from Upper Lake Lafayette to Lake Piney Z. Based on the bathymetric contour map for Lake Piney Z (given in Figure 2-4), the normal water level in Lake Piney Z ranges from approximately 45-46 ft. Existing bottom elevations of Upper Lake Lafayette are substantially lower than the water level in Lake Piney Z, suggesting that a gravity connection between Upper Lake Lafayette and Lake Piney Z would not be feasible. As a result, water discharging through the redirected channels would need to be pumped from Upper Lake Lafayette into Lake Piney Z using a relatively large pump station. A factor also not yet addressed is that most of the bottom of Upper Lake Lafayette is privately owned, requiring permission and possible purchase of bottom areas prior to implementation of this option.

The proposed runoff diversion option appears to have minimal impact on existing loadings of nitrogen and phosphorus entering Upper Lake Lafayette, while having a potential significant negative impact on water quality characteristics in Lake Piney Z. Additional protection provided for the sink area also appears to be minimal with this option. Transfer of water from Upper Lake Lafayette to Lake Piney Z will likely require pumping, further complicating this marginal option. Therefore, diversion of runoff from Upper Lake Lafayette to Lake Piney Z appears to be neither scientifically nor technically attractive at this time.

6.3.3 Construct Berm Around Sink Areas

A popular potential management technique among the Lake Lafayette Stakeholders is construction of earthen berms around the primary sink and significant smaller sinks to potentially create an open water or wetland habitat within Upper Lake Lafayette and minimize the amount of direct discharge of untreated runoff into the sinks. Specific details concerning the elevations and construction details of the proposed berms would need to be evaluated during the design phase for the berms.

Although this appears to be an attractive management option, there are many details which must be evaluated prior to implementation. The geology of areas beneath Upper Lake Lafayette is not well understood, and the possibility exists that the water pressure caused by impounding the inflows would open sinks in other portions of Upper Lake Lafayette, defeating the purpose of the berms. As a result, a detailed geologic survey would need to be performed as part of the evaluation phase for this option.

Another concern with this option is that inputs of baseflow and stormwater runoff would continue to infiltrate at a relatively high rate through the porous bottom areas of Upper Lake Lafayette and continue to contribute pollutant loadings to underground aquifers. The likelihood of this occurring depends, to a large extent, upon the geology and depth of soil layers beneath Upper Lake Lafayette. However, Harper (1988) demonstrated that surficial soils are extremely effective in attenuating stormwater pollutants during infiltration through the soil, particularly for phosphorus and heavy metals. Soil layers were found to be less effective for retaining nitrogen inputs. Nevertheless, even if relatively rapid infiltration were to occur through the soils of Upper Lake Lafayette, a substantial portion of the phosphorus, heavy metals, suspended solids, and bacteria loadings would be absorbed or incorporated into existing soils during the infiltration process. On the surface, this appears to be a relatively inexpensive retrofit option for Upper Lake Lafayette, although substantial additional hydrogeologic investigations are necessary prior to selection and implementation of this option.

The overall pollutant removal effectiveness of this option will depend, to a large extent, upon the type of open water or wetland habitat created after the berms are installed. This habitat will itself be dictated, to a large degree, by the depth of water which can be detained within Upper Lake Lafayette. However, regardless of the type of open water or wetland habitat which is created, the berms will create additional opportunity for assimilation of pollutants prior to discharge into the sinks. Since pollutant removal and attenuation in wet systems are regulated to a large extent by residence time, the berms should be designed to retain as much water as possible without compromising other areas within Upper Lake Lafayette.

6.3.4 Construct Treatment Systems for Weems Pond and Lafayette Creek Inflows

As discussed in Section 4, both Lafayette Creek and Weems Pond contribute substantial loadings of nitrogen, phosphorus, TSS, BOD, copper, and zinc into Upper Lake Lafayette. Therefore, improving water quality characteristics of these inflows appears to be a logical alternative for improving water quality in Upper Lake Lafayette.

A comparison of current and future loadings of total nitrogen and total phosphorus entering Upper Lake Lafayette from Weems Pond and Lafayette Creek is given in Table 6-18. The current and future loadings summarized in this table reflect the combined inputs from baseflow and stormwater runoff from each of the two sources. Based upon this analysis, loadings of total nitrogen appear to be slightly higher in the Weems Pond tributary, while loadings of total phosphorus and TSS appear to be greater in the Lafayette Creek watershed.

One useful method of evaluating impacts from a watershed area is to examine areal loadings in terms of kg of pollutant generated per acre of watershed area. Based upon information provided in Table 5-1, the Weems Pond basin has a total drainage basin area of 10,040 acres, including sub-basins designated as partially closed basins (PCB), with a drainage area of 8795 acres excluding the partially closed basins. In contrast, the Lafayette Creek sub-basin covers an area of only 1799 acres or approximately 18-20% of the area covered by the Weems Pond sub-basin. As a result, the areal loadings of nitrogen, phosphorus, and TSS generated in the Lafayette Creek basin are substantially greater than the areal loadings generated in the Weems Pond sub-basin.

Areal loadings of total nitrogen in the Lafayette Creek basin are approximately four times greater than areal loadings generated in the Weems Pond basin under both current and future conditions. Similarly, areal loadings of total phosphorus in the Lafayette Creek basin are approximately 5-6 times greater than areal loadings generated by the Weems Pond basin. Differences in areal loadings between the two basins are particularly apparent for suspended solids, with an areal loading rate for Lafayette Creek approximately 12 times greater than the areal loading exhibited by the Weems Pond tributary.

TABLE 6-18

COMPARISON OF CURRENT AND FUTURE LOADINGS ENTERING UPPER LAKE LAFAYETTE FROM WEEMS POND AND LAFAYETTE CREEK

a. Total Nitrogen

SOURCE	DRAINAGE AREA (acres)	CURRENT CONDITION		FUTURE CONDITION	
		Annual Load (kg/yr)	Areal Load (kg/ac-yr)	Annual Load (kg/yr)	Areal Load (kg/ac-yr)
Weems Pond	10,040/8795[1]	3563	0.35/0.41[1]	3770	0.38/0.43[1]
Lafayette Creek	1799	2953	1.64	2932	1.62

b. Total Phosphorus

SOURCE	DRAINAGE AREA (acres)	CURRENT CONDITION		FUTURE CONDITION	
		Annual Load (kg/yr)	Areal Load (kg/ac-yr)	Annual Load (kg/yr)	Areal Load (kg/ac-yr)
Weems Pond	10,040/8795[1]	845	0.08/0.10[1]	902	0.09/0.10[1]
Lafayette Creek	1799	1012	0.56	1023	0.57

c. TSS

SOURCE	DRAINAGE AREA (acres)	CURRENT CONDITION		FUTURE CONDITION	
		Annual Load (kg/yr)	Areal Load (kg/ac-yr)	Annual Load (kg/yr)	Areal Load (kg/ac-yr)
Weems Pond	10,040/8795[1]	124,417	12.4/14.2[1]	128,258	12.8/14.6[1]
Lafayette Creek	1799	274,132	152	263,516	146

1. Total basin area/basin area without partially closed basins (PCB)

The large differences in areal loading rates between the Weems Pond and Lafayette Creek sub-basins are due to two primary factors. First, the Weems Pond basin receives the benefit of treatment provided by Weems Pond. It is likely that this pond is highly effective in reducing inputs of total nitrogen, total phosphorus, and, particularly, TSS, retaining these loads within the pond and reducing the ultimate loadings reaching Upper Lake Lafayette. In contrast, the Lafayette Creek basin contains no significant treatment facilities to attenuate pollutant prior to reaching Upper Lake Lafayette.

The second factor involved is the substantial differences in stormwater characteristics measured within the two basins. The Lafayette Creek basin was found to exhibit substantially higher runoff concentrations for total nitrogen, total phosphorus, TSS, and BOD compared with concentrations typically observed in urban runoff. The combination of these two factors results in substantially elevated areal loadings discharging through Lafayette Creek.

Based upon the excessively high areal pollutant loadings discharging from the Lafayette Creek drainage basin, combined with the fact that the Weems Pond basin already has a substantial treatment facility, it appears most logical to concentrate additional treatment efforts in the Lafayette Creek basin. The most effective means of providing treatment for this basin would be construction of a regional stormwater management pond which could provide attenuation for pollutant discharges prior to entering Lake Lafayette.

A potential location for a treatment pond site in Lafayette Creek is indicated on Figure 6-4. The cleared area indicated in the photograph appears to be part of the stormwater management pond constructed during widening of Conner Road. The existing pond could be substantially enlarged within the existing cleared area or expanded into upland areas located north and west of the existing pond. Providing that hydraulic conditions are favorable, Lafayette Creek flow could be diverted into the expanded pond by constructing a diversion structure across the existing channel. Depending upon the available size of the pond, portions of runoff discharges through Lafayette Creek could be routed into the pond for treatment, with the remaining discharges bypassing the treatment system and discharging directly into Upper Lake Lafayette, as occurs under existing conditions. The amount of water and corresponding design storm events which could be diverted into the expanded pond site would depend upon the size of the pond and discharge characteristics of Lafayette Creek during modeled storm events.

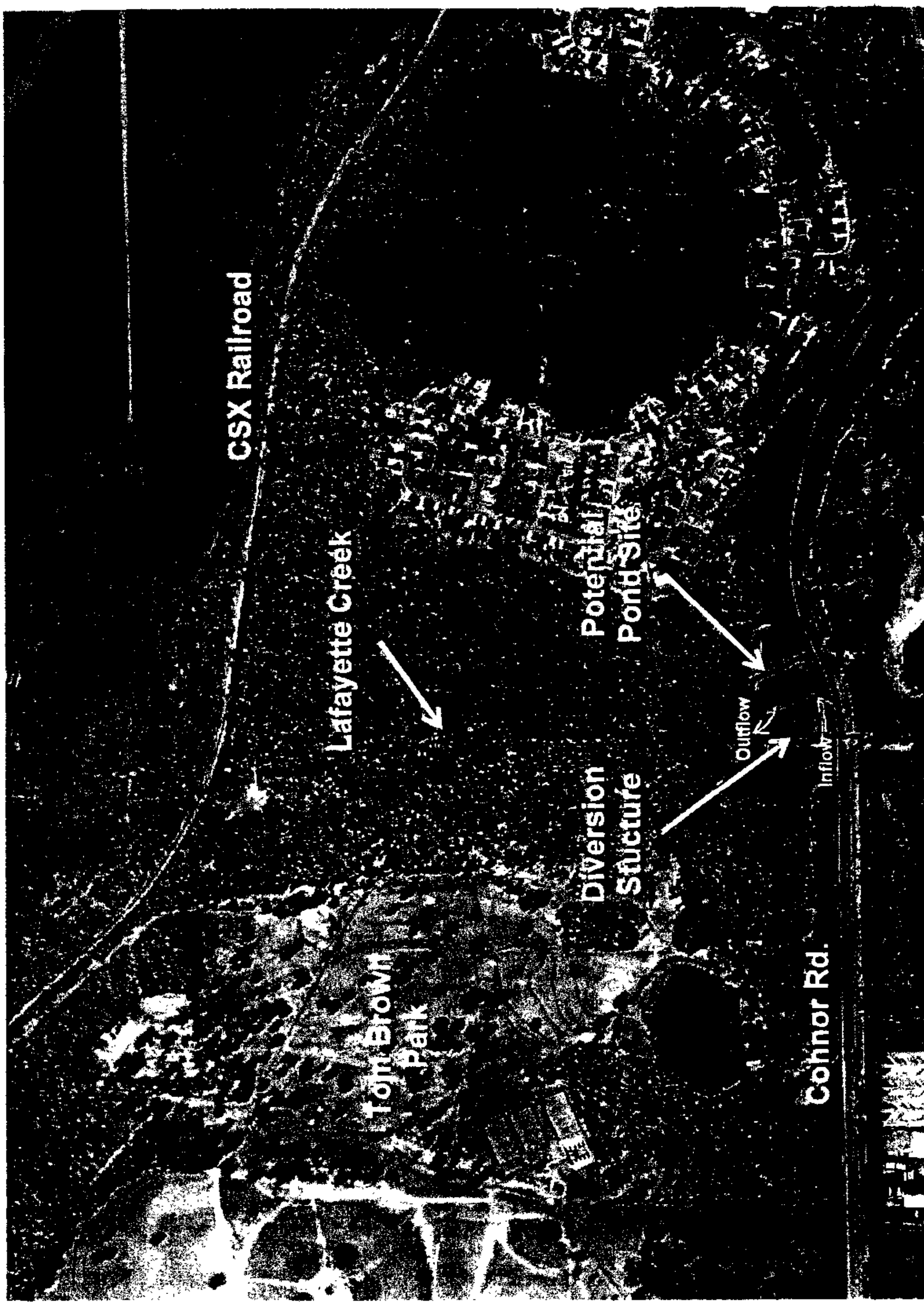

Figure 6-4. Location of Potential Treatment Pond Site for Lafayette Creek.

Although the specific treatment capacity of a potential pond at this site cannot be determined at this time, it appears reasonable to anticipate that a substantial amount of the existing suspended solids loadings could be removed within the pond even if a residence time of only a few hours could be achieved. The reduction in suspended solids loadings within the pond would also create a corresponding reduction in loadings of total nitrogen, total phosphorus, and heavy metals.

A second potential treatment option for treating inflows from Lafayette Creek is indicated on Figure 6-5. This option involves construction of a berm across Upper Lake Lafayette which would provide detention storage for inflows from both Lafayette Creek and the Weems Pond tributary. The specific height of the berm would need to be developed during the design phase for the project. The height of the berm would need to be constructed such that the water level would not interfere with the discharges through the Weems Pond tributary or Lafayette Creek during high level events, causing potential flooding in upstream portions of each sub-basin.

The berm indicated on Figure 6-5 could create a potentially large storage area which would naturally evolve into a wetland treatment system. The potential area available for this treatment system is much larger than the area currently occupied by Weems Pond and, as a result, a relatively long detention time and a correspondingly high level of treatment could be anticipated within this system. This area could provide a substantial opportunity for suspended solids to settle out along with the associated pollutant loadings. In addition, a valuable open water/wetland habitat would be created which could be utilized for recreational purposes. An overflow weir would be constructed within the berm to allow excess water to discharge into the remaining portions of Upper Lake Lafayette.

Before the berm could be constructed, a thorough geologic investigation of the impounded area should be undertaken to ensure that there are no potential sinks which may open once the area becomes impounded with water. The impoundment created by the bermed area will substantially reduce the volume of water which discharges downstream and into other portions of Upper Lake Lafayette, reducing the volume of water which discharges down the main sink.

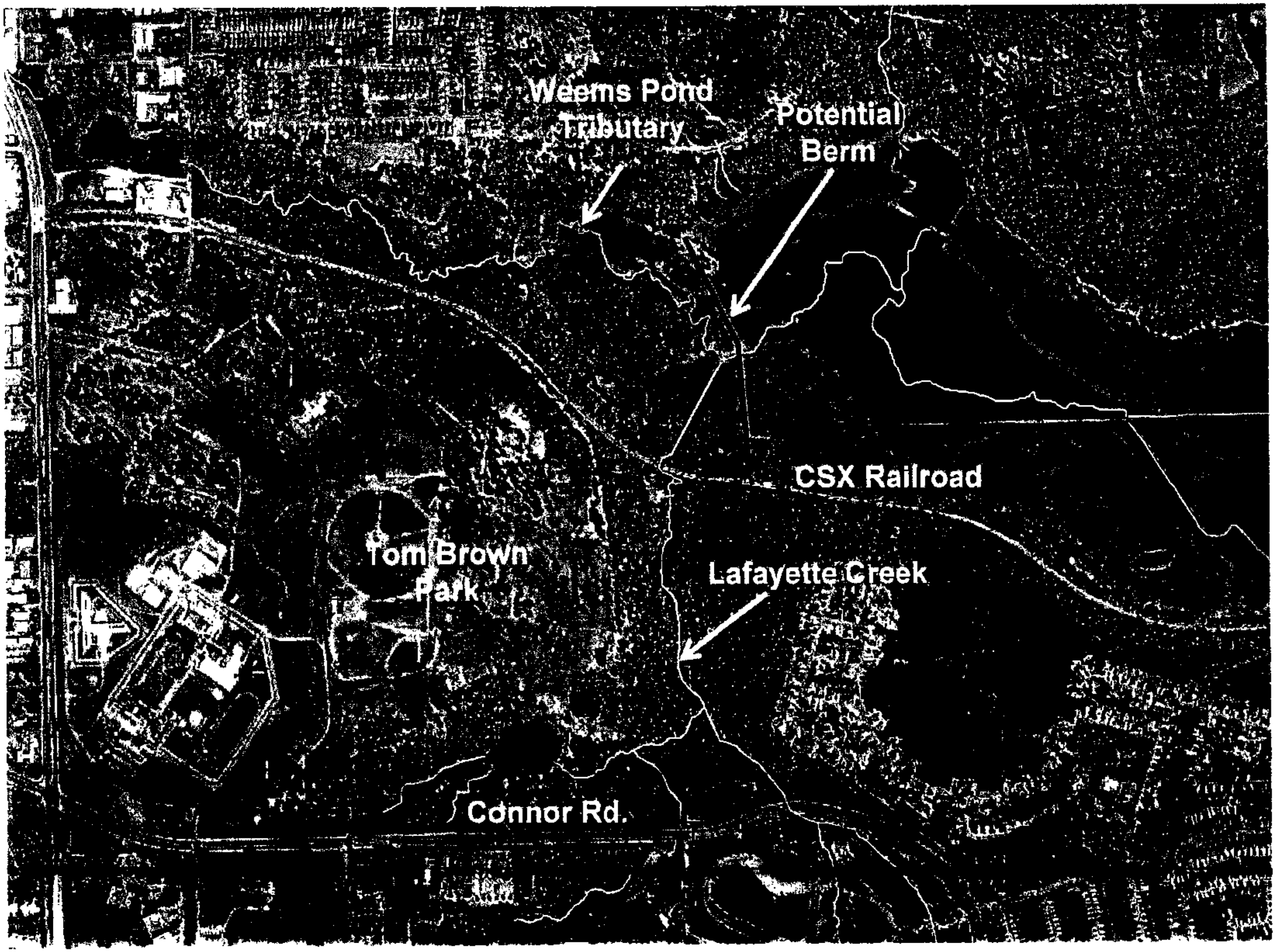

Figure 6-5. Location of Potential Berm for Treating both Weems Pond Tributary and Lafayette Creek.

However, as indicated previously, virtually all of the bottom areas of Upper Lake Lafayette are currently in private ownership, and creating an impoundment within this area would require either a long-term easement or direct purchase of the property from the existing owner. However, if these obstacles can be overcome, this appears to be an extremely attractive alternative due to the relatively low initial capital costs and low annual O&M costs associated with this option.

A final treatment option is illustrated in Figure 6-6 which would provide chemical treatment for discharges from both the Weems Pond and Lafayette Creek tributaries. A settling pond would be constructed in the western portion of Upper Lake Lafayette in an area where both tributaries could discharge by gravity flow. Discharges from Weems Pond and the Lafayette Creek tributaries would be diverted into the settling pond, and liquid alum would be injected into each of the two inflows upstream from the point of inflow into the pond. The chemical precipitate formed by addition of alum to the tributary inflows would settle within the pond area, and the clarified supernatant would then discharge from the east side of the pond into Upper Lake Lafayette. Diversion weirs would be used to divert baseflow and certain storm events into the pond for treatment. Larger storm events could then bypass the pond and discharge into Upper Lake Lafayette through the current inflow channels.

The removal efficiencies associated with alum treatment are highly predictable. Alum treatment is highly effective in reducing concentrations of phosphorus, heavy metals, and bacteria. Typical removal efficiencies achieved during alum treatment of stormwater runoff are summarized in Table 6-19. In general, alum treatment will provide approximately 80-90% reduction in total phosphorus, 40-50% reduction in total nitrogen, 60% reduction in BOD, and 85-95% reduction in TSS. Since the pond will be used only for settling and collection of the precipitate, the residence time within the pond would be approximately 24 hours or less, substantially reducing the required volume of the pond compared with volumes typically utilized for wet detention treatment. The floc precipitate generated during the treatment process can be removed and disposed of in a variety of ways, including disposal into the sanitary sewer system or land spreading.

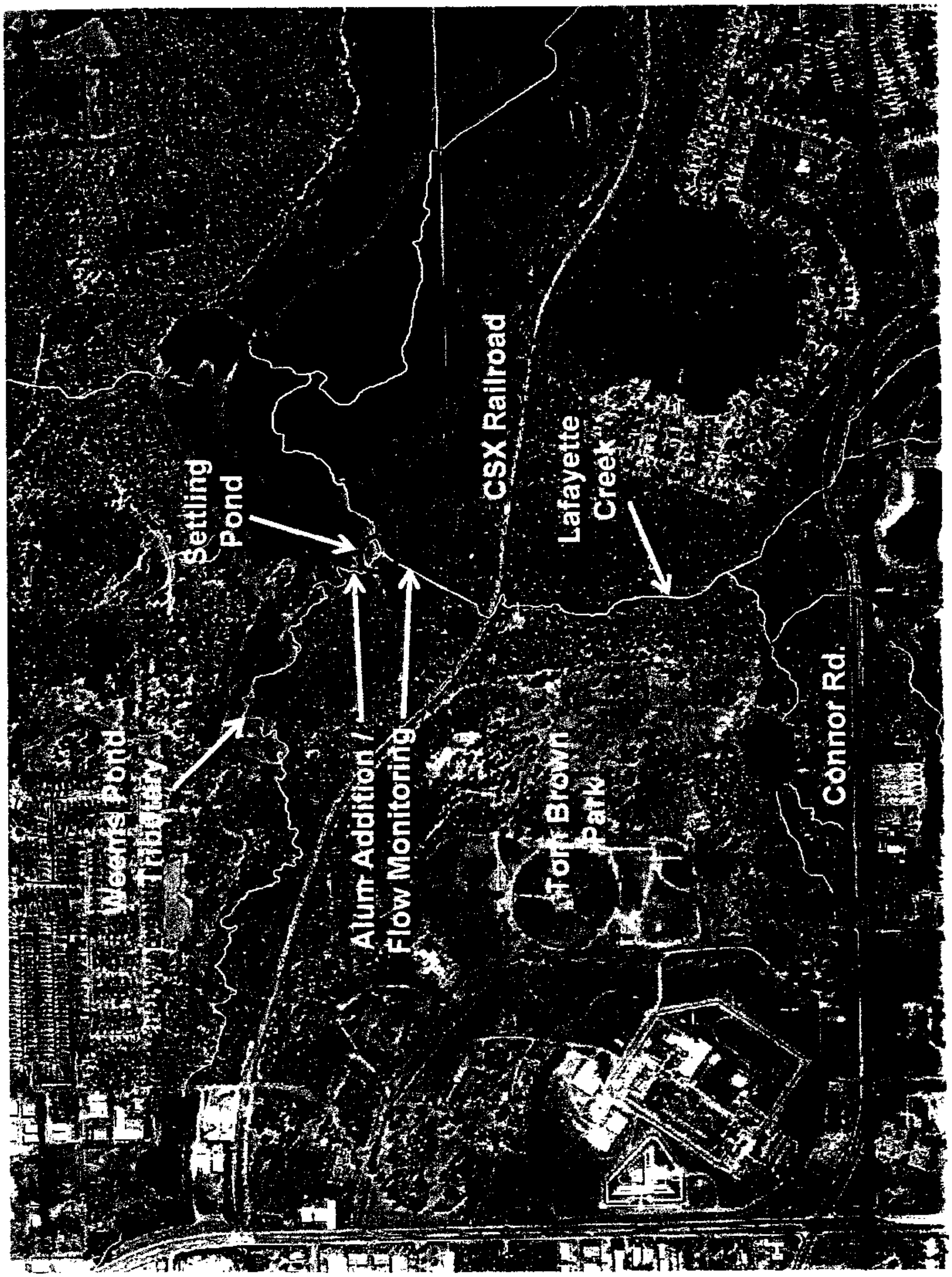

Figure 6-6. Chemical Treatment Option for Weems Pond and Lafayette Creek Tributaries.

TABLE 6-19

TYPICAL REMOVAL EFFICIENCIES FOR
ALUM TREATMENT OF STORMWATER RUNOFF

CONSTITUENT	REMOVAL
Total N	40-50
Total P	80-90
BOD	60
TSS	85-95
Cadmium	70-90
Copper	70-90
Chromium	70-90
Lead	70-90
Zinc	70-90
Fecal Coliform	90 - >99

The alum treatment of stormwater inflows from the Weems Pond and Lafayette Creek tributaries will provide a substantial reduction in annual mass loadings of total nitrogen, total phosphorus, BOD, TSS, heavy metals, and bacteria into the sink area of Upper Lake Lafayette. In addition, a substantial removal is also achieved for a wide variety of organic compounds which are also possible contaminants into the sink. This appears to be a potentially attractive treatment alternative due to the extremely high removal efficiencies achieved and the relatively small commitment of available land required. The alum treatment alternative may be the only option capable of achieving the required reductions in bacteria counts.

The alum treatment alternative could also be utilized to treat Lafayette Creek only using the potential pond site illustrated in Figure 6-4 as a settling pond for collection of the floc. Construction of this system would be relatively simple, requiring only a diversion structure, flow metering equipment, and alum injection equipment in addition to the settling pond. A substantially smaller pond would be needed, compared with typical requirements for wet detention systems, since a detention time of 24 hours or less is typically required for complete settling of the floc. This option would also substantially reduce loadings into Upper Lake Lafayette which are generated in Lafayette Creek, although it would provide no additional treatment for discharges from Weems Pond.

6.4 Management Options for Lake Piney Z

Lake Piney Z is currently managed as a fishery by the Florida Fish and Wildlife Conservation Commission. As summarized in Table 6-1, existing water quality concerns revolve around low dissolved oxygen levels, elevated BOD, and elevated *E. Coli* measurements.

Under existing conditions, Lake Piney Z is an open water system with excessive amounts of both emergent and submergent aquatic vegetation. The abundant aquatic vegetation minimizes the ability of the water column to circulate and transfer oxygen from the water-air interface into deeper portions of the water column. As a result, the abundant aquatic vegetation may actually be creating conditions which enhance development of low dissolved oxygen concentrations. In addition, Lake Piney Z contains a number of berms which extend into the waterbody, further isolating portions of the lake and restricting water movement in general.

Unless Lake Lafayette is restored to a single waterbody, the most appropriate use for Lake Piney Z appears to be continuance of the existing fishery operations. As discussed in Section 2, the Florida Fish and Wildlife Conservation Commission has placed approximately 6000 grass carp in Lake Piney Z to assist in vegetation control, and spraying is currently performed to control floating hyacinths. These vegetation control efforts should be continued. As vegetation is controlled within the lake, particularly floating water hyacinths, opportunity for reaeration of dissolved oxygen should be enhanced. Therefore, the only management alternative recommended for Lake Piney Z at this time is continuation and perhaps enhancement of the existing vegetation control efforts.

6.5 Management Options for Alford Arm

6.5.1 Vegetation Control

Under current conditions, the majority of Alford Arm is heavily vegetated with both submergent and emergent vegetation. The growth of hydrilla also appears to be rampant throughout open water portions of Alford Arm. The extent of the existing vegetation makes recreational activities within Alford Arm extremely difficult.

Vegetation control is essential to enhancing public access within this portion of Lake Lafayette. Although the vegetation is probably beneficial from a water quality perspective, the existing coverage could be reduced substantially without significantly impacting water quality.

Vegetation control in Alford Arm should be significantly enhanced to provide open water or even trails which could be used by the public for recreational purposes. The dense growth of hydrilla and submerged vegetation makes motor boating, and even non-motorized boating, extremely difficult. This submerged vegetation would need to be controlled if motor boating activities are desired. However, non-motorized access could be achieved by cutting trails and maintaining the existing vegetation with an aquatic harvester. These trails could create a unique opportunity to observe wildlife in a natural isolated setting. Grass carp could also be utilized in this portion of Lake Lafayette, although the discharge culverts beneath the CSX railroad would need to be modified to prevent migration of the fish to Lower Lake Lafayette.

One of the largest problems in Lake Lafayette is the presence of floating tussocks which clog the existing discharge pipes and make navigation throughout Alford Arm difficult and dangerous. An aggressive harvesting program should be conducted to harvest and remove this floating vegetation from the lake. This will assist in providing open water areas for recreational activities as well as a mechanism for removal of nutrients from Alford Arm.

6.5.2 Removal of Dikes/Berms

As discussed in Section 2.3, at least six berms can be identified in aerial photography which both impound and restrict water movement within portions of Alford Arm. It is thought that these berms were originally constructed to create permanent water pools for agricultural purposes, and some of these pools continue to be utilized for these purposes under existing conditions. However, the presence of these berms restricts the opportunity for navigation and recreation within Alford Arm and creates periodic flooding concerns.

A number of the Lake Lafayette stakeholders have expressed a desire for removal of the existing berms within Alford Arm to restore this portion of Lake Lafayette to its natural free-flowing condition and to eliminate flooding which has occurred in certain portions of Alford Arm. Although removal of the berms in Alford Arm may appear to be a desirable goal, the berms actually perform a useful purpose by providing valuable open water habitats amongst the otherwise dense vegetation and by increasing detention for inputs of baseflow and stormwater into Alford Arm, improving water quality and reducing mass loadings which would otherwise discharge into Lower Lake Lafayette. The open water habitat created by the berms also increases the recreational opportunities within Alford Arm which would otherwise be severely limited due to the excessive growth of vegetation.

In view of the apparent benefits created by the existing berms and dikes in Alford Arm, careful consideration should be given to the purpose and function of each berm prior to recommendation for removal. Only those dikes and berms which cause severe flooding under existing conditions should be considered for removal. Future development which occurs within Alford Arm should be required to consider the flooding potential created by the remaining berms in the design for the development and should not be allowed to exacerbate existing flooding conditions.

Although removal of some of the existing dikes and berms may be necessary, it appears that there are substantial benefits from maintaining at least some of the berms for habitat variability, recreational opportunities, and pollutant load reductions to Lower Lake Lafayette. A significant obstacle to removal of the existing dikes and berms is that large portions of Alford Arm are currently privately owned. Any activities related to the dikes and berms will require consent of the existing property owners or purchase of the property by a governmental agency.

6.5.3 Improve Hydraulic Connections Between Alford Arm and Lake Lafayette

Several of the Lake Lafayette stakeholders suggested that the hydraulic connections between Alford Arm and Lower Lake Lafayette be improved to reduce flooding which has occurred within Alford Arm. These improved hydraulic connections would increase both the rate and volume of water which discharges from Alford Arm to Lower Lake Lafayette on an annual basis.

As discussed in Section 2.2.3, hydraulic connections between Alford Arm and Lower Lake Lafayette currently consist of two 30-inch RCPs in the CSX railroad berm, two 54-inch RCPs near the western end of the CSX berm, and four-to-six 24-inch steel pipes set at a high invert which discharge only under high water conditions. These hydraulic connections, particularly the two 30-inch RCPs and two 54-inch RCPs, function as culverts with the discharge rate a function of the relative water elevations in Alford Arm and Lower Lake Lafayette.

Estimated discharge rates through the existing culverts in Alford Arm and Lower Lake Lafayette are summarized in Table 6-20 based on various elevation differences between Alford Arm and Lower Lake Lafayette. Since these culverts are generally submerged, the discharge through the culverts is primarily a function of the difference in water level surface between Alford Arm and Lower Lake Lafayette. Estimated discharge rates are provided for the two 30-inch RCPs and the two 54-inch RCPs at elevation differences of 0.5, 1.0, 1.5, and 2.0 ft. Total estimated discharge through the existing culverts, not including the four-to-six 24-inch steel pipes, ranges from approximately 166-332 cfs. As a result, the existing culverts are capable of transporting a substantial amount of water from Alford Arm into Lower Lake Lafayette even at a relatively low head differential.

TABLE 6-20

ESTIMATED DISCHARGE RATES THROUGH THE EXISTING CULVERTS FROM ALFORD ARM TO LOWER LAKE LAFAYETTE

ELEVATION DIFFERENCE BETWEEN ALFORD ARM AND LOWER LAKE LAFAYETTE (ft)	DISCHARGE THROUGH TWO 30-INCH RCPs (cfs)	DISCHARGE THROUGH TWO 54-INCH RCPs (cfs)	TOTAL DISCHARGE (cfs)
0.5	35.8	130.2	166.0
1.0	50.6	184.1	234.7
1.5	62.0	225.4	287.4
2.0	71.6	260.3	331.9

Based upon observations by ERD personnel, Leon County staff, and various stakeholders, conveyance of water from Alford Arm into Lower Lake Lafayette is frequently restricted due to clogging of the existing conveyance mechanisms by floating vegetation and tussocks. The existing pipes appear to have substantial conveyance capability between the two compartments, but this conveyance is often limited due to the presence of the vegetation. Therefore, the most effective and least costly mechanism for improving the hydraulic connections between Alford Arm and Lower Lake Lafayette is to maintain a free-flowing connection for the existing conveyance pipes.

The existing dense vegetation and floating tussocks in the vicinity of the discharge pipes should be aggressively controlled to maintain the capacity of the hydraulic connections. An aggressive vegetation harvesting program should be conducted to maintain open water in the vicinity of the pipes. An alternative method of preventing vegetation from clogging the culverts would be installation of a bar screen, perhaps with 6-8 inch spacing between the bars, in a semi-circle, with a radius of perhaps 10 ft, around the entrance to each culvert. These bar grates would prevent large mats of floating vegetation from clogging the culverts while still allowing substantial movement of water beneath the floating vegetation.

6.5.4 Stormwater Treatment for Alford Arm Tributary

A potential method for reducing nutrient and pollutant loadings to Alford Arm is to construct a regional stormwater treatment facility to treat the Alford Arm tributary prior to discharge into Alford Arm. Leon County currently owns a parcel along the Alford Arm tributary, immediately south of Buck Lake Road. This area could be converted into a wet detention facility or other type of treatment process to reduce nutrient loadings entering Alford Arm.

As seen in Table 4-11, inputs of baseflow and runoff through the Alford Arm tributary contribute approximately 21% of the annual nitrogen loadings and 19% of the annual phosphorus loadings entering Alford Arm. If a wet detention facility were to be constructed, and sufficient space were to be available to provide a 14-day residence time for inputs into the pond, the treatment pond would achieve approximately 60% reduction in annual phosphorus loadings and a 20% reduction in annual nitrogen loadings. Overall, this pond would provide an 11% (19% x 0.6) reduction in total phosphorus loadings to Alford Arm and a 5% (21% x 0.25) reduction in total nitrogen loadings to Alford Arm. These reductions are relatively minimal in terms of the overall loadings reaching Alford Arm and would probably not result in measurable water quality improvements within Alford Arm.

As seen in Table 4-11, the most significant loadings into Alford Arm occur as a result of direct runoff from land areas immediately adjacent to Alford Arm. These directly connected areas currently contribute approximately 47% of the total nitrogen loadings to Alford Arm and 65% of the total phosphorus loading. Therefore, a substantially higher level of water quality improvement could be achieved by providing stormwater treatment for existing areas adjacent to Alford Arm either under current conditions or as the parcels become developed under future conditions. However, construction of a regional stormwater treatment facility for the Alford Arm tributary does not appear to be a practical alternative for reducing nutrient loadings at this time.

6.6 Management Options for Lower Lake Lafayette

Lower Lake Lafayette is arguably the most ecologically valuable portion of Lake Lafayette. This portion of the lake contains a wide variety of habitats which include cypress swamps, areas of open water, emergent aquatic vegetation, and freshwater marsh. One of the most significant features in Lower Lake Lafayette is the wood stork rookery which is located between Alford Arm and Chaires Road. There is virtually unanimous agreement between the Lake Lafayette stakeholders that this wood stork rookery is a significant asset in Lower Lake Lafayette which must be preserved.

The only management activities which appear warranted in Lower Lake Lafayette at this time are continued control of vegetation within the lake, particularly in western portions of Lower Lake Lafayette adjacent to Lake Piney Z, and in northern portions adjacent to Alford Arm. These areas contain dense stands of aquatic vegetation as well as floating tussocks which make recreational access into Lower Lake Lafayette difficult. Lower Lake Lafayette is a unique ecological resource which could provide outstanding recreational opportunities if access into the area could be enhanced. Vegetation control in Lower Lake Lafayette should be enhanced to provide open water or even trails which could be used by the public for canoeing or kayaking. These trails or open water areas would provide unique opportunities for the public to view wildlife in a relatively unaltered setting. Vegetation control should be achieved, if possible, by harvesting rather than spraying to remove the nutrient loadings associated with the vegetation. Therefore, enhanced vegetation control and increased recreational opportunities are recommended for Lower Lake Lafayette.

6.7 General Management Options

Management options are discussed in this section which are general in nature and not specifically directed toward any of the four compartments of Lake Lafayette. The general options include alternative stormwater regulations, source controls and public education, conversion of the lake into a single lake system, improved recreational opportunities, and development of tributary and waterbody buffers for the Lake Lafayette basin. Each of these alternatives is discussed in the following sections.

6.7.1 Alternative Stormwater Regulations

As discussed in Section 6.2, annual mass loadings of total nitrogen, total phosphorus, TSS, and BOD are projected to increase in Upper Lake Lafayette, Alford Arm, and Lower Lake Lafayette under future conditions as development occurs within the Lake Lafayette drainage basin. These increases are predicted in spite of stormwater management systems which are currently required for new development in Leon County. Significant increases in nutrient loadings are projected in Alford Arm and Lower Lake Lafayette under future conditions which will exacerbate the existing problems with vegetative growth in these compartments.

One alternative for minimizing the impacts of future development on Lake Lafayette is to implement alternative stormwater regulations within the Lake Lafayette drainage basin similar to those recently implemented for the Bradfordville area. These regulations are designed to achieve the goal of no net increase in pollutant loadings as a result of development under future conditions compared with loadings discharging from existing parcels under current conditions. Implementation of these regulations in the Lake Lafayette basin would assist in maintaining the existing loadings entering each of the four compartments of Lake Lafayette which are summarized in Table 6-8. However, these new regulations would only prevent further degradation of Lake Lafayette under future conditions and would not solve existing water quality problems exhibited in some of the compartments.

The alternative regulations developed for the Bradfordville area rely heavily upon dry retention and wet detention as stormwater treatment alternatives. Dry retention systems are effective in areas with permeable soils, typically classified in hydrologic soil groups A and B.

As seen in Figure 5-4, and summarized in Table 5-4, approximately 80% of the Lake Lafayette basin contains soils which are suitable for dry retention systems. This type of stormwater management system relies upon infiltration into the ground to remove the stormwater mass and provide treatment. Wet detention systems rely upon creation of a man-made lake and are usually constructed in areas within hydrologic soil groups C and D. Approximately 17% of the Lake Lafayette basin is suitable for construction of this type of stormwater management facility. Therefore, based upon the existing soils located in the Lake Lafayette basin, it appears that alternative regulations similar to those developed for the Bradfordville area are feasible within this basin.

Based upon the existing water quality impairment in Lake Lafayette, and the potential for further degradation as development occurs within the basin, it is recommended that alternative stormwater regulations be implemented within the Lake Lafayette basin for future development with the goal of no net increase in loadings above those which exist under current conditions. These regulations are already in place in portions of the Lake Lafayette basin located in the Bradfordville area. Although these regulations will prevent further degradation of water quality in Lake Lafayette, additional water quality improvement projects will still be needed to mitigate existing water quality concerns.

As an alternative to implementing the stringent stormwater regulations currently in force in the Bradfordville area, modifications could be made to existing Leon County design criteria for stormwater management systems. Currently, Leon County authorizes construction of dry detention with filtration systems for stormwater management in new developments. As indicated in Table 5-9, dry detention systems with or without filtration exhibit relatively poor treatment efficiencies for common stormwater constituents. The treatment effectiveness of these systems, particularly dry detention with filtration, is highly dependent upon the relationship between the underdrain and the groundwater table. Systems which are constructed with the underdrain intercepting the groundwater table can actually export more nutrients on an annual basis than enter the system from stormwater runoff. Because of the poor performance of these systems, it is anticipated that the use of dry detention and dry detention with filtration will ultimately be phased out within the State of Florida.

To evaluate potential impacts of eliminating dry detention as a stormwater treatment alternative in Leon County, the LLNSLMM model was run for future conditions, with stormwater treatment provided only by dry retention and wet detention. The areas which were assumed to be treated by dry detention or dry detention with filtration under future conditions were reallocated to either dry retention or wet detention, based on the relative proportion of these facilities under current conditions. Both of these system types exhibit substantially higher pollutant removal efficiencies than dry detention. Elimination of dry detention as a stormwater treatment alternative will reduce some of the projected increases in mass loadings for future development. Therefore, ERD strongly recommends that Leon County modify its existing stormwater regulations to eliminate all forms of dry detention as a stormwater treatment methodology within Leon County.

6.8 Source Controls and Public Education

Source controls and public education are non-structural methods for reducing pollutant loadings within a watershed. These methods are designed to reduce the generation and accumulation of stormwater contaminants, preventing these contaminants from entering the stormwater flow. A discussion of source controls and public education is given in the following sections.

6.8.1 Stormwater Pollution Prevention Plans

Development of stormwater pollution prevention plans should be required for all new developments in the Lake Lafayette watershed. Pollution prevention plans discuss non-structural controls which are intended to improve the quality of stormwater runoff by reducing the generation and accumulation of potential stormwater runoff contaminants at or near the respective sources for each constituent. A stormwater pollution prevention plan should include guidelines in the areas of: (1) nutrient and pesticide management; (2) street sweeping; (3) solid waste management; and (4) stormwater treatment system operation and maintenance. An example of a generic stormwater pollution prevention plan is given in Appendix F.

Many of the methodologies and procedures outlined in a stormwater pollution prevention plan are general best management practices (BMPs) which may be used for attenuating pollutants in many types of urban settings. However, each stormwater pollution prevention plan should be tailored to meet the specific character of each proposed development, including the surrounding and constructed drainage features.

One of the primary aspects of a stormwater pollution prevention plan is a discussion of nutrient and pesticide management. This usually consists of a series of practices designed to manage the use of fertilizers and pesticides so as to minimize the loss of these compounds into stormwater runoff and the resulting water quality impacts on adjacent waterbodies. Nutrient and pesticide management plans typically discuss landscape planning, application of fertilizers and pesticides, and guidelines to minimize the necessity for the use of pesticides and fertilizers. The nutrient management program can also place restrictions on the percentage of nutrients contained in fertilizers which are used within the development. This can be used to target specific nutrients, typically nitrogen in estuarine environments, which are problematic in the ultimate receiving waterbody. Pesticide management programs typically restrict the use of pesticides, fungicides, or herbicides to products which are consistent with the USDA NRCS soil rating for the specific soils, and which minimize the potential of leaching into groundwater or surface water.

Another aspect of a comprehensive stormwater pollution prevention plan is street sweeping. This practice is becoming increasingly more popular to minimize inputs of pollutants into stormwater runoff. Street sweeping activities can be particularly effective during periods of high leaf fall by removing solid leaf material and the associated nutrient loadings from roadside areas where they can easily become transported by stormwater flow. Previous research has indicated that leaves release large quantities of both nitrogen and phosphorus into surface water within 24-48 hours after becoming saturated in an aquatic environment. Loadings to waterbodies from leaf fall are often the most significant loadings to receiving waters during the fall and winter months. Street sweeping operations are typically performed on a monthly basis, with increased frequency during periods of high leaf fall.

A comprehensive stormwater pollution prevention plan may also contain information regarding the type and operation of stormwater management systems for the community. This document will describe the basic elements of the stormwater management system to better inform the residents who may potentially impact the operation of the system. The plan will also discuss maintenance of the detention pond, and emphasize that the proper operation of the system depends on cooperation from all homeowners involved.

Stormwater pollution prevention plans are typically attached as deed restrictions for new developments. As such, the provisions of the stormwater pollution prevention plan can be enforced by the Property Owners Association (POA), including assessing fines and placing liens on the property of homeowners who do not adopt the pollution prevention procedures.

Although it seems reasonable that a properly designed stormwater pollution prevention plan can reduce inputs of pollutants into stormwater runoff, no comprehensive studies have been conducted to document the reductions in loadings which can be achieved by this mechanism. Several studies are currently underway within the State of Florida which will address this issue during the next few years.

Anticipated load reductions for implementation of stormwater pollution prevention plans can be highly variable, depending upon the degree of implementation by the impacted homeowners. Load reductions as high as 20% can be achieved for total nitrogen, total phosphorus, and BOD, based upon full implementation of the nutrient and pesticide management aspects of the stormwater pollution prevention plan. Assuming a sweeping frequency of approximately once per month, street sweeping has been shown to remove approximately 15% of the total nitrogen load, 20% of the total phosphorus load, 25% of BOD, and 50% of TSS. Street sweeping is also a non-structural control which can be used outside of the stormwater pollution prevention plan to reduce pollutant loadings from existing developed land uses which may not have stormwater treatment facilities. Anticipated load reductions for implementation of stormwater pollution prevention plans are summarized in Table 6-21.

The costs for development and implementation of a stormwater pollution prevention plan will fall primarily on the developer and the homeowners of the developed community. The costs to governmental agencies for implementation of this option are considered to be negligible.

TABLE 6-21

ANTICIPATED LOAD REDUCTIONS
FOR IMPLEMENTATION OF STORMWATER
POLLUTION PREVENTION PLANS

PARAMETER	PLAN ELEMENT	
	NUTRIENT AND PESTICIDE MANAGEMENT[1]	STREET SWEEPING[2]
Total N	0-20	15
Total P	0-20	20
BOD	0-20	25
TSS	0-50	50

1. Depending upon degree of implementation
2. Based on a sweeping frequency of once per month

The only foreseeable economic impact on homeowners for implementation of a nutrient and pesticide management plan may be the increased cost of specially-formulated fertilizers which meet the nutrient content restrictions outlined in the nutrient management plan. Assuming that the specialized formulations increase the cost of the fertilizer approximately $5 per 50-pound bag, and assuming that the average homeowner applies five 50-pound bags of fertilizer twice each year, the average cost per homeowner would be approximately $50 per year.

The cost for street sweeping activities would be spread out among the homeowners within the community, and the fee per individual will depend upon the number of homeowners within a given community. Street sweeping costs are currently approximately $40/curb mile for brush-type street sweepers, with slightly increased costs for the newer vacuum-type machines.

6.8.2 Public Education

Although public education is an element of stormwater pollution prevention plans, as presented in the previous section, additional opportunities for public education should be undertaken in the Lake Lafayette watershed. These opportunities are particularly important for existing residents which are not part of a planned community and are not covered by a stormwater pollution prevention plan. Public education is one of the most important nonpoint source controls which can be used in a watershed. Many residents appear to be unaware of the direct link between watershed activities and the water quality in adjacent waterbodies and estuaries. The more a resident or business owner understands the relationship between nonpoint source loadings and receiving water quality, the more that person may be willing to implement source controls.

Several national studies have indicated that it is an extremely worthwhile and cost-effective activity to periodically remind property owners and occupants of the potential for water quality degradation which can occur due to misapplication of fertilizers and pesticides. Periodic information pamphlets can be enclosed with water and sewer bills which will reach virtually all residents within the watershed. These educational brochures should emphasize the fact that taxpayer funds are currently being utilized to treat nonpoint source water pollution, and the homeowners have the opportunity to reduce this tax burden by modifying their daily activities. A comprehensive public education program should concentrate, at a minimum, on the following topics:

1. Relationship between land use, stormwater runoff, and pollutants
2. Functions of stormwater treatment systems
3. How to reduce stormwater runoff volume
4. Impacts of water fowl and pets on runoff characteristics and surface water quality
5. County stormwater program goals and regulations
6. Responsible use of fertilizer, pesticides and herbicides
7. Elimination of illicit connections to the stormwater system
8. Controlling erosion and turbidity
9. Proper operation and maintenance of stormwater systems

The public education program can be implemented in a variety of ways, including homeowner and business seminars, newsletters, performing special projects with local schools (elementary, middle and high schools), Earth Day celebrations, brochures, and special signage at stormwater treatment construction sites. Many people do not realize that stormsewers eventually drain to area lakes. Many cities and counties in Florida have implemented a signage program which places a small engraved plaque on each stormsewer inlet indicating "Do Not Dump, Drains to

Lake". ERD recommends that an aggressive public education program be implemented in the Lake Lafayette watershed which incorporates all of the elements discussed previously.

Anticipated load reductions for implementation of public education programs are difficult to predict and depend highly upon the degree of implementation by the homeowners within the basin. The impacts of public education programs also depend, to a large extent, on the degree to which water quality within the Lake Lafayette basin is currently being impacted by uneducated and uninformed activities by current homeowners.

Virtually no previous studies have been conducted to evaluate the water quality impacts resulting from improved homeowner education programs. Several regional and national studies are currently being performed which will attempt to document the results of public education programs. However, the actual load reductions achieved by public education programs will probably be relatively small, probably in the range of 10% each for nitrogen, phosphorus, BOD, and TSS.

Costs for public education programs can be highly variable depending upon the intensity of the education program and the types of media used to reach individual homeowners. A simple newsletter placed in a utility bill would be a relatively inexpensive method of reaching many of the residents in the Lake Lafayette watershed.

6.9 Restoration of Lake Lafayette to a Single Lake System

One of the most discussed restoration options by the Lake Lafayette stakeholders is restoration of Lake Lafayette into a single lake system similar to its historic configuration. Although restoration of Lake Lafayette to its natural state appears to be a desirable goal, there are many obstacles which stand in the way of this option.

Elimination of the berms which separate Lake Piney Z from Upper Lake Lafayette and Lower Lake Lafayette would create one unified waterbody out of these compartments. However, this connection would transfer portions of the existing excessive nutrient loadings present in Upper Lake Lafayette into Lake Piney Z as well as Lower Lake Lafayette. The additional nutrient loadings in Lower Lake Lafayette would further stimulate the growth of aquatic vegetation and algae, reducing the recreational value of these resources. Elimination of Lake Piney Z would reduce the recreational and fishing opportunities which currently exist

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within this compartment since water levels would be substantially lower. In addition, connection of Upper Lake Lafayette to other portions of Lake Lafayette would allow more water to discharge into the sink areas, increasing the potential for groundwater contamination within the aquifer. As discussed previously, portions of the bottom of Lake Lafayette are currently in private ownership, and conversion of the lake into a unified waterbody would require either permission from the private owner or purchase of the property by a governmental agency.

Even if Upper Lake Lafayette, Lake Piney Z, and Lower Lake Lafayette were to be reconnected, it is unlikely that the existing connection with Alford Arm could be re-established. The existence of the CSX railroad berm prevents this reconnection under current conditions. Re-establishment of the connection would require either relocation of the railroad or construction of an elevated platform and bridge structure for much of the length of the railroad crossing through Alford Arm. In addition, Alford Arm currently provides significant nutrient and pollutant uptake for water prior to reaching Lower Lake Lafayette. Re-establishment of a free-flowing connection between Alford Arm and Lower Lake Lafayette would result in additional nutrient loadings to Lower Lake Lafayette which would further decrease the recreational value of this area and may affect food source availability for the wood stork rookery.

Although the existing compartmentalization of Lake Lafayette is unfortunate, each of the four compartments provides unique recreational opportunities and water quality benefits for the other compartments within the lake. Therefore, ERD cannot recommend reconnection of the compartments of Lake Lafayette at this time.

6.10 Improved Recreational Opportunities

The Lake Lafayette stakeholders were virtually unanimous in the opinion that recreational opportunities should be enhanced throughout Lake Lafayette. Given the variety of recreational opportunities which are potentially available, and the unique habitat provided in certain portions of Lake Lafayette, this appears to be a valuable management option.

A graphical depiction of land in public ownership adjacent to Lake Lafayette is given in Figure 6-7. The City of Tallahassee currently owns portions of Upper Lake Lafayette, Lake Piney Z, and western portions of Lower Lake Lafayette. Western portions of Alford Arm are

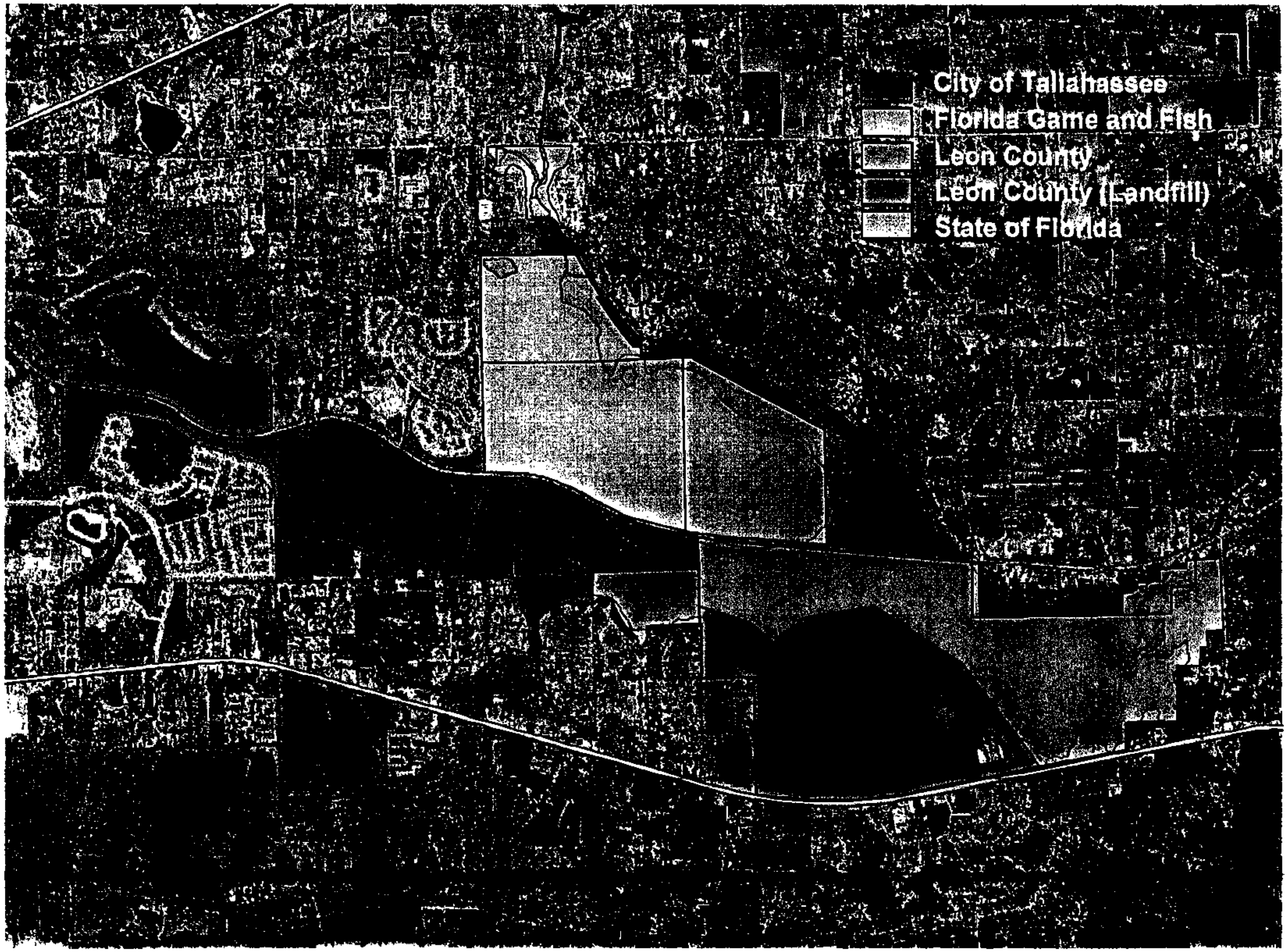

Figure 6-7. Land in Public Ownership Adjacent to Lake Lafayette.

currently in the ownership of the State of Florida. Large portions of Lower Lake Lafayette are currently owned by the Florida Fish and Game Commission and Leon County. It appears that significant land is already in public ownership, and no additional purchase of land appears necessary to enhance recreational opportunities within Lake Lafayette.

Although a substantial amount of land is already in public ownership, recreational opportunities into the lake are relatively limited. Fishing opportunities are currently available in Lake Piney Z but no significant facilities are available to support this recreation. Similarly, the public can access Alford Arm through land owned by the State of Florida, however this requires hiking to reach the lake. No significant public access is currently available through lands owned by the Florida Fish and Game Commission into Lower Lake Lafayette.

Leon County and other governmental agencies should consider construction of dedicated recreational facilities to allow public access into all portions of Lake Lafayette. Lake Lafayette contains unique habitat which could become a benefit to many citizens in Leon County. These recreational opportunities should include trails or roadways so that the general public can gain access to the various portions of the lake. Canoe or kayak trails could be set-up, particularly in Lower Lake Lafayette, to provide better access into this unique ecosystem. Therefore, ERD strongly recommends that additional recreational opportunities and infrastructures be constructed to provide additional public access into Lake Lafayette.

6.11 Recommended Management Options

A summary of recommended management options for Lake Lafayette is given in Table 6-22 based upon the information and discussions provided in the previous sections. For Upper Lake Lafayette it is recommended that berms be constructed around the sink areas to retain as much water as possible within the remaining portions of Upper Lake Lafayette. This will provide additional opportunity for pollutant attenuation prior to discharge into the sink for infiltration through the bottom soils. In addition, construction of a treatment system for Lafayette Creek is also recommended in view of the extraordinarily high areal loadings discharging through this tributary. This treatment system could be dedicated to Lafayette Creek itself, or combined with a treatment system for Weems Pond, as indicated in Figure 6-5.

TABLE 6-22

RECOMMENDED MANAGEMENT
OPTIONS FOR LAKE LAFAYETTE

COMPARTMENT	RECOMMENDED MANAGEMENT OPTION
Upper Lake Lafayette	1. Construct berms around sink areas 2. Construct treatment system for Lafayette Creek (or Lafayette Creek/Weems Pond)
Lake Piney Z	1. Continue and expand vegetation control/removal 2. Provide additional public access
Alford Arm	1. Continue and expand vegetation control/removal 2. Provide additional public access 3. Provide bar screens to eliminate clogging of culverts
Lower Lake Lafayette	1. Continue and expand vegetation control/removal 2. Provide additional public access
General	1. Implement alternative stormwater regulations to achieve no net increase in post-development loadings 2. Revise stormwater ordinance to exclude all forms of dry detention 3. Require new development to develop source control plans 4. Implement public education program

For Lake Piney Z, it is recommended that the existing vegetation control and removal processes be continued and expanded to maintain and enhance the recreational value of this waterbody. It is recommended that this portion of Lake Lafayette be maintained as a fishery, with additional public access provided into this area.

In Alford Arm, it is recommended that vegetation control and removal be continued and expanded to maintain areas of open water and access into the waterbody for recreational opportunities. Additional public access and facilities are needed to attract the public into this area. It is also recommended that bar screens be constructed around the culverts which discharge from Alford Arm into Lower Lake Lafayette to prevent vegetation from clogging the culverts and restricting flow.

In Lower Lake Lafayette, additional vegetation control and removal is recommended to remove areas of nuisance vegetation as well as floating tussocks. Facilities for additional public access into this unique portion of Lake Lafayette are highly recommended.

In addition to the specific recommendations for each compartment of Lake Lafayette, a series of general recommendations is also provided. First, it is recommended that alternative stormwater regulations be implemented for the Lake Lafayette watershed similar to those previously implemented in the Bradfordville area. The intent of these regulations is to provide sufficient stormwater treatment to achieve no net increase in post-development loadings discharging into Lake Lafayette. This alternative will prevent further degradation of Lake Lafayette and may improve existing water quality violations.

As an alternative to implementing alternative stormwater regulations to achieve no net increase in post-development loadings, it is recommended that the Leon County stormwater ordinance be revised to exclude all forms of dry detention. This type of stormwater treatment system exhibits poor removal efficiencies and is currently being eliminated in many areas of the state.

All new development should be required to develop source control plans which will be designed to reduce the generation and sources of stormwater pollutants within watersheds. This appears to be an extremely cost-effective alternative, since the cost of implementation is relatively minimal.

Leon County should implement a public education program within the Lake Lafayette watershed to educate citizens on the relationship between stormwater and receiving water quality. This education program should include ideas for general citizens to reduce personal pollution.